United States
Department of
Agriculture

Forest Service

Intermountain
Research Station
Ogden, UT

General Technical
Report INT-207

May 1986

Proceedings— Grizzly Bear Habitat Symposium

Missoula, Montana,
April 30—May 2, 1985

FOREWORD

The grizzly bear (Ursus arctos horribilis) once ranged throughout most of the Western United States. Excessive mortality and loss of suitable habitat resulted in a significant decline in the distribution and abundance of the grizzly. Today, an estimated 750 to 1,000 grizzlies occur in portions of Montana, Wyoming, Idaho, and Washington. This represents about 1 percent of the bear's historical range, and also about 1 percent of its original range. The Interagency Grizzly Bear Committee (IGBC), established in 1983, plays a major role in the conservation and management of the grizzly. The IGBC is composed of Regional Directors of the Fish and Wildlife Service and National Park Service, three Forest Service Regional Foresters, Montana State Director of the Bureau of Land Management, and State wildlife agency directors or representatives from the States of Idaho, Montana, Washington, and Wyoming. The primary objective of the IGBC is to serve as the coordinating mechanism for research and management related to grizzly bear in the lower 48 States.

The IGBC sponsored this symposium with the Center for Continuing Education and the School of Forestry, University of Montana. The symposium was presented by the Forest Service (Northern, Rocky Mountain, Intermountain, and Pacific Northwest Regions), and the Intermountain and Rocky Mountain Research Stations. It represents the first time a major effort has been directed specifically to grizzly bear habitat management. These proceedings are intended to provide scientists, educators, managers, and the interested public with the most advanced knowledge and technology regarding grizzly bear-habitat interrelationships.

The following individuals contributed significantly to the development and presentation of the symposium:

Program Committee:	Glen Contreras, Chairman, Forest Service, Intermountain Region Bob Gale, Forest Service, Siuslaw National Forest L. Jack Lyon, Forest Service, Intermountain Station Christopher Servheen, Fish and Wildlife Service Lorin Ward, Forest Service, Rocky Mountain Station Dale Wills, Forest Service, Rocky Mountain Region
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Approximately 350 participants from land management agencies, industry, colleges and universities, and Federal and State research organizations attended.

It is hoped that the information contained within these proceedings will enlighten all of us to a better understanding of habitat management for the grizzly and enhance our appreciation for coexistence with the "great bear."

Stan Tixier

STAN TIXIER
Symposium General Chairman
1986-87 Chairman IGBC

Proceedings—Grizzly Bear Habitat Symposium

Missoula, Montana, April 30—May 2, 1985

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Symposium Sponsored by:

Interagency Grizzly Bear Committee
University of Montana
  School of Forestry
  Center for Continuing Education

Symposium Presented by:

Forest Service, U.S. Department of Agriculture
  Northern Region
  Rocky Mountain Region
  Intermountain Region
  Pacific Northwest Region
  Intermountain Research Station
  Rocky Mountain Forest and Range Experiment Station

Proceedings Published by:

Intermountain Research Station, Federal Building,
324 25th St., Ogden, UT 84401

CONTENTS

Session I—Habitat Concerns

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MANAGING POLITICAL HABITAT FOR GRIZZLY BEAR RECOVERY

John E. Burns

ABSTRACT: Although the level of scientific knowledge about grizzly bears and their habitat has significantly advanced in recent years, the application of that knowledge by management agencies has not consistently followed a holistic strategy incorporating human needs, grizzly needs, and political realities. As a result, recovery of the grizzly has been controversial, opposition to management practices has occurred, and political involvement is intensifying. In some instances, managers and key public and political figures disagree about biological questions. For the most part, however, the conflicts and controversy stem from the perceived exclusion of human needs and values by administrators. In a natural resource question so complex as the grizzly, unanimity cannot realistically be expected; however, if grizzly recovery is to be achieved, researchers and managers must develop broad support for a total management strategy based on human as well as bear needs.

DISTRIBUTION AND MANAGEMENT

Historic and Current Distribution

Although grizzly bears roamed throughout the Western United States early in the last century, only six areas in the conterminous 48 States supported self-perpetuating or remnant populations of grizzlies by the time the Grizzly Bear Recovery Plan was prepared in 1982 (U.S. Department of the Interior 1982).

The six areas vary considerably in topographic, climatic, and vegetative characteristics, as well as habitat capabilities and apparent bear densities. The largest populations are found in the northern Continental Divide grizzly bear ecosystem (NCDGBE) and the Yellowstone grizzly bear ecosystem (YGBE). Estimates of bear density are some three times greater in the NCDGBE, although the areas of occupied habitat are roughly equal in size. The other grizzly ecosystems--north Cascade, Silkirks, Cabinet-Yaak, and Selway-Bitterroot--are smaller and contain limited or remnant populations (U.S. Department of the Interior 1982).

Geopolitical Habitat Distribution

All of the grizzly bear ecosystems (GBE's) are within the States of Washington, Idaho, Montana, and Wyoming, and encompass portions of numerous National Forests, several National Parks, State lands, U.S. Department of the Interior, Bureau of Land Management administered public domain lands, and private lands. Rural and incorporated communities are within, surrounded by, or adjacent to grizzly habitat. The Yellowstone GBE is perhaps the most geopolitically complex, with parts of the occupied habitat in three States, two National Parks, five National Forests, State lands, BLM lands, and multiple counties. Several towns and rural communities are within or close to occupied habitat, as are privately owned ranch, recreational, and resort lands.

Recovery Plan and Management Guidelines

Management and research efforts have focused on the animals, their habitat, and the effects of human activities and natural resource use on both. The recovery plan provides an overall framework for managers, and ecosystem-localized guidelines have been adopted or are being prepared. These guidelines, such as the <u>Guidelines for Management Involving Grizzly Bears in the Greater Yellowstone Area</u> (Yellowstone Guidelines) adopted in December 1979, provide refined guidance for managers weighing alternative courses of action in grizzly habitat (U.S. Department of

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Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30 - May 2, 1985.

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Agriculture 1979). The Yellowstone guidelines also provide a framework for responding to occasional situations such as "problem bears." Site-specific guidance is also provided, as in the Targhee National Forest Draft Land Management Plan, which incorporates the Yellowstone Guidelines as basic management direction and further refines those guidelines with site-specific direction for subunits of the Forest´s management areas (Orme and Williams in preparation; U.S. Department of Agriculture 1981).

THE YELLOWSTONE GRIZZLY BEAR ECOSYSTEM

Management Direction and Public Perceptions

Occupied grizzly habitat in the Yellowstone region encompasses 5.5 million acres, mostly within the Shoshone, Bridger-Teton, Targhee, Gallatin, and Custer National Forests and Yellowstone and Grand Teton National Parks. The habitat is stratified by situations (I through V) in accordance with the Yellowstone Guidelines (U.S. Department of Agriculture 1979). The habitat stratification was implemented after the guidelines were adopted in 1979 and for several years was considered set. Neither the guidelines nor the situation stratification was subject to the National Environmental Protection Act (NEPA) process, nor were nonagency publics urged to participate to any significant degree, a fact which recently has politically clouded the legal status of the guidelines.

Concerns about Yellowstone grizzly management followed close on the heels of park tourism. In fact, early visitors such as Theodore Roosevelt commented on the problems associated with bear use of hotel garbage dumps in the Park. So strong is the relationship between bears and garbage that debate on current bear management practices often alludes to the closure of the Yellowstone dumps (Hackett 1983; National Park Advisory Board 1985). The ripple effect of the action to eliminate the bears´ dependency on human foods extends throughout bear habitat far beyond the Park boundaries. In the view of some, such as sheep rancher Bill Enget, dump closures cause the bear problems (Koon 1984). The issue is further intertwined with debate over the effects of supplemental feeding, baiting, human use of grizzly habitat, and other management actions (Boyd 1984; Hackett 1983; Koon 1984; Simpson 1985a).

Numerous agencies and individuals have been involved with grizzly management and research in the last decade. As they have developed grizzly policy and implemented it, the public and members of the political structure have all too often perceived lack of common purpose (Koon 1984; Melnykovych 1985) and have consequently questioned the competence and even motivation of key participants (Boyd 1984; Hackett 1983; Ogden Standard-Examiner 1984; Snodgrass 1984; Simpson 1985b). If the "experts" do not agree, the public may well ask, do they know what they are talking about?

Management Implications of Grizzly Population and Mortality

The population of Yellowstone GBE was estimated at 200 to 350 grizzlies when the recovery plan was written (USDI 1982). More recently, the Interagency Committee adopted a minimum population estimate of 183 to 207 bears. Regardless of the precise number, which is obviously difficult to establish, managers found themselves faced with an apparently low population and information suggesting a proportionately small breeding female bear population of 30 or fewer animals. Given the known rate of grizzly mortality, the small breeding population indicates a marginal ability of the Yellowstone population to sustain itself. On the heels of this disquieting information, 14 known human-caused bear mortalities and 3 natural mortalities occurred in 1982 (table 1). Logically, managers and researchers concluded that the immediate thrust of bear recovery should be to reduce human-caused mortality, with particular concern for breeding females (Mehrhoff 1982).

Table 1 depicts known mortality by generalized cause for the period 1980 through 1984, based on a composite of agency records and annual reports (Orme 1984). These 48 known bear deaths yield an average loss to the system of 9.6 bears each year, with 1982 showing the most known losses (17) and 1983 the fewest (6). No definitive trend over time is discernible from the data, but the information suggests certain activities that have contributed consistently to mortality and warrant management attention.

Surprising, perhaps, is the relative lack of mortality associated with resource use such as grazing or timber harvest (table 1). Large parts of the occupied habitat are within National Parks and National Forest wilderness, but a significant portion is within National Forest and other land ownership where timber

harvest, grazing, and other resource use takes place.

None of the mortality for this 5 year period is confirmed to be directly involved with such National Forest resource use or related activities, but the first year of the Bear 38 incident did involve National Forest grazing (Matejko and Franklin 1983). One other bear mortality indicated in table 1 is possibly linked to grazing activity and is under continuing investigation. In any case, known human-induced mortality or losses for the past 5 years are largely related to recreational activities such as camping or hunting, and the attractants associated with areas of human habitation such as West Yellowstone, Montana.

Efforts of managers, however, have not always been guided by the latest information or by hard-nosed interpretation of basic data limitations and reliability (Burns 1981b). Unfortunately, this has fueled the public perception of disagreement among managers, contributed to the alienation of important segments of the local economic and social structures, and resulted in political reaction limiting or altering the management latitude for recovery, as is discussed later.

Table 1.--Yellowstone GBE known mortality by cause for 1980 through 1984

Year	Known mortality or loss	Natural causes[1]	Unknown causes	Road (vehicle)	Hunter related[2]	Self defense[3]	Control export[4]	Handling accident[5]
1984	9	1	2	0	0	1	3	2
1983	6	(1)[6]	0	0	0	0	4	2
1982	17	3	1	0	5	1	5	2
1981	9[7]	2	1	1	4	1	0	0
1980	7	2	0	1	2	0	1	1
Total	48	8	4	2	11	3	13	7
Ave Year	9.6	1.6	0.8	0.4	2.2	0.6	2.6	1.4

[1] Usually malnutrition,

[2] Includes some apparent poaching incidents,

[3] All hunter-involved self-defense incidents,

[4] Includes bears which were killed for public safety as well as those turned over to zoos,

[5] All associated with research, export, or relocation efforts,

[6] Cub of control action-bear not expected to survive winter,

[7] In 1981 an additional six unverified mortalities were reported.

NOTE: A hunter related mortality for 1984 has since been verified, which increases the total known loss for 1984 to 10 bears, the average/year hunter related loss to 2.4.

TARGHEE NATIONAL FOREST

Use of Mortality Data in Section 7 Consultations

An examination of the pre-1980 mortality statistics for the Targhee National Forest (table 2) provides insight into why political controversy has ensued from their use. Initial estimates of sheep-related bear mortality were compiled from annual grazing reports and other sources (Jorgensen 1979). After adjustments to eliminate duplication, this estimate formed the basis for the 1960-79 mortality figures included in the biological evaluation submitted by the Targhee National Forest as part of the Section 7 consultation on grazing in grizzly habitat (Lee 1981).

The mortality data summaries tended to be widely accepted as a definitive portrayal of mortality associated with sheep allotments before 1980; in fact those who developed these summaries recognized serious difficulties with the raw information (Burns 1981b; Lee 1981; Jorgensen 1979). More significantly, managers and others often overlooked the fact that the grizzly was not classified as "threatened" until 1975, and the grazing-associated mortality before that date--of whatever magnitude--was legal (table 2). After listing of the grizzly on August 1, 1975, the situation altered drastically. Before 1975, not only did State law permit and tend to encourage the killing of livestock predators, but the very cultural fabric and economic necessity of the livestock industry provided strong incentives to do so. From a legal and administrative point of view, the acceptability of grizzly mortality completely reversed in 1975 as a result of listing. Conclusions about past mortality patterns could be drawn from judicious use of the data, but with the drastic change from a legally sanctioned act (when killing grizzly to protect stock) to a felonious act meant the information could not be used to project future mortality patterns (Burns 1984f).

The level of mortality shown for 1976 to 1979 in table 2 suggests that mortality continued or even increased on some sheep allotments following listing of the bear. When, however, we understand that only one of those seven (bear No. 14) was a known loss (Lee 1981), another aspect of the data is brought to light: how much weight should be placed on unverified reports as a basis for management (Burns 1982b)?

To place the mortality data in perspective and gauge its reliability and implications, the origin of the information must be understood. The historical record of losses developed from a variety of sources, but relied heavily on grazing reports filed annually with the U. S. Department of Agriculture, Forest Service, and other information provided by the grazing permittees. Estimates by different investigators for similar periods varied greatly and were difficult to reconcile (Griffel 1976a; Johnson 1976; Knight and Judd 1980). The grazing reports typically list losses of livestock to various causes such as predation, accident, or poisonous plants, as well as predators killed. For the most part a permittee relies on information provided by herders. The local ranger in turn relies on information submitted by the permittee.

In evaluating raw data reliability, one must keep in mind that aside from outright guesses by permittees and rangers, incentives existed for exaggeration or misstatement. A poor herder who loses 20 sheep by letting them pile up in a gully and suffocate may find it expedient to attribute the loss to a bear, rather than to inattention or error. In addition, narratives of bear incidents tend to be repeated and even enhanced, and such narratives repeatedly enter the reporting and investigating system as "incidents." As a result, unverified, "word-of-mouth" stories contribute to the incident reports and to mortality estimates. Such data have contributed to the tally of unverified losses, such as six of the seven from 1976 to 1979. As the aggregation or summarization process flows, the limitations placed on the initial data tend to be obscured (Burns 1982b).

Effect of Mortality Patterns on Bear Recovery Programs

The point, of course, is not to dispute the estimated number of kills developed from various sources but to point out that these estimates, once formulated, were taken by many at face value, which contributed to strong reaction against sheep use of grizzly habitat. Persons and organizations active in bear recovery relied heavily on the estimates to build public opinion and implied that the livestock owners would likely continue to shoot grizzlies near their flocks (Knight and Judd 1980; Griffel 1976b; McNamee 1984.) Using the 1960-79 mortality estimates to draw attention to the bear's

Table 2.--Grizzly bear mortality on sheep allotments, Targhee National Forest

Years	Two-Top/Reas allotments	Squirrel/Boone allotments	Other allotments
1960	2		
1965	1		
1966	1		
1967	1		
1968	1		
1969	2		
1970	5	2	
1971	1	2	
1972	2	1	1
1973	1	2	1
[1]1974-75	2	1	
1976-79		[2]7	
1980-84			[3]1

[1] Grizzly "listed" as threatened on August 1, 1975. Mortality for 1960 through 1975 legal under State laws.

[2] Bear 14 mortality only one of the seven "incidents" that could be verified.

[3] In 1984, a mortality of unknown cause was verified on a sheep allotment not in situation 1 habitat. It is under investigation.

plight was highly successful in one sense but also alienated the sheep ranchers, who felt they were being singled out as the scapegoat. To those attempting to build a broad-based consensus for bear recovery, continuous finger-pointing at the grazing industry was counterproductive (Burns 1982a).

Section 7 Consultation and No-Jeopardy Opinion

By 1980, Forest Service personnel and sheep permittees had arrived at an adjusted pattern of grazing in the Targhee's Situation 1 bear habitat, which was submitted for formal Section 7 Consultation in 1981 (Lee 1981). This pattern was intended to minimize bear-livestock conflict potential by providing room to maneuver for the grazing operations, as well as by avoiding certain areas of historic bear-sheep contact such as Winegar Hole. During this period, the economic situation in the sheep industry encouraged having smaller numbers on the range, a trend that no doubt made the adjusted pattern of reduced numbers and allotment consolidations easier to achieve. Table 3 shows the permit "obligation" (number of mature animals under permit and the number of allotments open) in situation 1 grizzly habitat in 1975, 1980, and 1984.

This adjustment, coupled with Targhee plans for intensive on-site monitoring of grazing activity and bear use in situation 1, received a U.S. Fish and Wildlife Service no-jeopardy opinion

(Mehrhoff 1981). A key element of the opinion was the aggressive monitoring program outlined by the Forest. Supplemental consultation on later adjustments in the grazing season received a similar no-jeopardy opinion (Mehrhoff 1982) indicating that the grazing program did not constitute a threat to the continued existence of the grizzly.

TREND OF POLITICAL INVOLVEMENT

Centennial Mountains Wilderness-Sheep-Grizzly Conflict

By coincidence, during this period of adjustment the BLM began a wilderness study of its existing BLM Centennial Mountains primitive area, located on the Montana side of the Centennial Range. The area is not within situation 1 habitat. The U.S. Sheep Experiment Station summer rangelands lay within the primitive area, and the wilderness study evolved into a sheep-grizzly controversy. The issue was settled when provisions in the appropriation legislation for BLM prohibited further use of funds for the wilderness study (Burns 1981a). Subsequently, the Sheep Station lands in question were transferred from BLM jurisdiction to the Department of Agriculture. Since then, the wilderness study has resumed but with mandatory exclusion from study of the rangelands used by the Sheep Station.

Message to Managers

To managers accustomed to the historical interactions of the political process with controversial or intense land management questions, the prohibitive legislation was not surprising. First through the appropriations process and then through direct action, Congress simply defined certain boundaries of politically unacceptable bear habitat. The larger message, however, was clear to those who chose to heed it: if managers do not make bear recovery and traditional land uses compatible, the legislative process will resolve the disputes. Other conflicts involving threatened or endangered species have followed a similar pattern when the social or economic structure was significantly affected. The snail darter-Tellico Dam controversy (Campbell 1983) is perhaps the most well known example. In the Rockies, the question of wolf reintroduction seems headed in the same direction (New York Times 1985).

Bear 38 Incidents

Unfortunately, compatibility between uses was elusive. In the late summer of 1983 the protracted incident of Bear 38 and her two offspring, Nos. 101 and 102, took place (Matejko and Franklin 1983). The bears killed sheep, first on the Two-Top allotment and later on private ranch lands. Because the private lands abutted

Table 3.--Number of allotments and permitted sheep numbers in situation 1 grizzly habitat, Targhee National Forest

Year	Number of open allotments [1]	Number of sheep [2]
1975	11	10,600
1980	6	6,200
1984	3	3,000

[1] Data for 1980 reflect consolidation of allotments and reduction in numbers as a result of Forest Service effort to reduce conflict potential in grizzly habitat, as well as effect of personal-convenience nonuse by permittees. Data for 1984 reflect additional effect of personal-convenience nonuse by permittees, plus temporary shift of Two-Top band of 1,100 head to allotments in Centennials to avoid repetition of Bear 38 interaction.

[2] Figures are mature animals. Normally, mature ewes under permit will be accompanied by one or two lambs.

the situation 1 boundary (also the Forest boundary), the focus of the incident became the agencies' collective ability--or willingness--to respond to "on-and-off" movements of the bears (that is, out of situation 1 onto private land and back) plus the need for more visible decision making during a bear incident. A well-attended public meeting included Congressional staff, local State legislators, county officials, numerous ranchers, and local residents. Considerable correspondence followed between legislators and administrators on incident authority and procedures for coping with problem bears when both private land and situation 1 were involved (McClure and Symms 1983; Siddoway 1983; Tixier 1984a,b). Again, a clear message was being sent to make political and biological habitats compatible.

Attempted Resolution

In an effort to defuse growing political concern, the Targhee Forest proposed supplemental language to the Yellowstone Guidelines which would identify a specific leader to handle such incidents as well as assure private landowners that constructive actions were being taken (Burns 1984c). Forest personnel cautioned that a failure to respond constructively could result in appropriations or legislative restrictions, as well as risk opening the Yellowstone Guidelines to review and possible modification. Considerable discussion of the proposals took place during 1983 and 1984, but managers did not agree to adopt the proposed changes (Buterbaugh 1985).

Later Management Actions

In 1984, in an effort to prevent a probable recurrence of bear-sheep conflict on Two-Top with Bears 38, 101, and 102, the sheep were shifted (over the objection of the permittee) to an alternate group of allotments outside situation 1 (Burns 1984a,b,d,e; Rigby 1984; Symms 1984). A conflict involving Bear 38 did take place but on private land outside the National Forest adjacent to the Two-Top allotment (Matejko and Franklin 1984). These events, plus concern for population augmentation elsewhere, resulted in the predicted appropriations restrictions, as well as requirements to publish the Yellowstone Guidelines in the Federal Register, hold public meetings to receive comment, and process the guidelines through the Federal rule-making procedure (Buterbaugh 1985). Additional legislative provisions were included to compensate permittees who incurred moving costs due to grizzly management actions (U.S. Laws 1985; Coston 1984).

THE POLITICAL FUTURE

Reality of Congressional Compromise

The message of Congress was clear in the 1985 Continuing Appropriations Act, but will it be heeded by managers? Unfortunately, the subtle functioning of our political process is often not fully appreciated by those deeply involved in controversial issues. Indeed, the temptation exists to perceive the outcome of issues in terms of how the votes might line up or where the majority of the United States population might stand if the specific issue somehow came to referendum. Too often overlooked is the fact that Congress is designed to produce compromise, and elected representatives must constantly balance national perspective against constituent desires (Kennedy 1964). The Senate, in particular, traditionally functions to respect the wishes of the State delegation, particularly if members occupy important committee or party positions. Consequently, the U.S. Senators involved in the grizzly issue in the Yellowstone area exercise a much greater level of influence and control than might be expected from a cursory assessment of the "national balance of power" on threatened and endangered species questions.

A temptation also exists to discount the trend of the political concern. An Audubon representative, speaking recently at the Idaho Woolgrowers Convention, cautioned the livestock interests that in a direct confrontation between their industry and the bear, they would lose (Idaho Wool Growers Bulletin 1984). Although this is possibly true, another view suggests that the political structure is responding to a much wider range of constituents' concerns about bears--not just the grazing-grizzly questions.

The Breadth of Public and Political Concern

The range of concern and interactions of external publics can be illustrated by a few examples: Future use of the unique grizzly habitat at Fishing Bridge in Yellowstone National Park is the subject of intense social, economic, and political interest. The issue of relocating visitor facilities is being debated not just on what is best for the bears but best for the economies of Teton and Park Counties, WY, the city of Cody, park concessionaires, and others (U.S. Department of the Interior 1985). Elsewhere, Ron Marcoux speaking for the State of Montana and the International Association of Fish and Wildlife Agencies (1985) before a Congressional subcommittee observed "we are left without substantive influence in actions originating from this Act (T&E Act), while bearing their consequences." Montana and the Association urge a "partnership" in managing the bear. A Wyoming biologist publicly expresses concern that bear experts are "losing their credibility," as well as control of the situation and public respect (Melnykovych 1985) and suggests limited hunting. An outfitter in grizzly country insists "the interests of the people who use the National Forests are being ignored" (Snodgrass 1984). His statements that unnecessary regulations and closures will adversely affect the sportsman, livestockman, lumberman, and so on are not falling on deaf or unsympathetic ears. Similar voices are making themselves heard throughout grizzly country (Buterbaugh 1985), and the political process is reflecting them (Simpson 1985a,b).

The crucial factor is not whether support for grizzly recovery can overcome conflicting individual interests such as livestock, timber, black bear hunters, recreationists, and tourist services, but whether these disparate interests--each of which rightly or wrongly perceives a threat in the current course of grizzly management --will coalesce and prompt further political delineation of grizzly habitat and management practices. The result may or may not conform to biological habitat and, if history is a guide, the two will not perfectly match.

PROSPECTS FOR MERGING BIOLOGICAL AND POLITICAL HABITAT

Effect of Restrictions

Managers still have time to refine and channel a grizzly recovery effort that incorporates all facets of the social and political structure. Many positive efforts are taking place, but managers must remember that each additional restriction imposed in grizzly habitat by definition must adversely affect someone, some action, or some interest. The list of bear opponents tends to widen regardless of how desirable any given restriction is to recovery. Each year sees additional actions such as eliminating black bear baiting, moving grazing permittees, food storage requirements, seasonal use limitations, and so on. Constraints are obviously necessary, and some historic uses must continue to evolve and change, but the modifications need to be made in a way that builds friends for the bear, not enemies.

Expression of Social Needs

Social needs and their expression through the political process typically differ from locality to locality. Even the most casual observer will note that the residents of Jackson Hole, WY, have somewhat different perspectives on natural resources utilization and management than do the residents of Teton or Fremont Counties, ID. Similar levels of differing perspective occur elsewhere, but managers must increasingly focus on finding a socially acceptable common denominator for bear management actions. The concept of grizzly recovery still enjoys virtually universal acceptance, but it is folly to take broad-based public support for granted or to ignore the social complexities of the public living with or close to the grizzly (Montana Department of Fish, Wildlife and Parks 1985).

Since its inception, the Forest Service has recognized that local support by National Forest users is vital to success of any management effort. And where local or regional support has been lost, or could not be obtained, national programs have ultimately changed. No better example exists than the history of the establishment of the National Forests themselves: broad authority was given by Congress to the Executive Branch to create forest reserves from the public domain, that authority was later removed

for most of the Western States, and the National Forests were subsequently opened to homesteading as a "safety valve" to prevent loss of the system altogether (Pinchot 1972). Overall, the management practices for the various activities on the National Forests, such as grazing, result far more from social evolution and consensus building than Federal rule-making (Roberts 1963).

Complexities of Recovery Consensus

The critical components of a consensus or broad support for a grizzly management strategy probably differ in each GBE. No study, or indeed comprehensive effort, has yet been undertaken to identify bear-related social and political issues on an ecosystem basis. Lacking that, the absence of a framework to integrate grizzly recovery with other public issues or concerns is not surprising. Local managers do attempt to meld the recovery effort with the social and political climate in their zones of influence, but this is not always fully effective, lacking as it does the flexibility or latitude for compromise needed to obtain broad-based support for natural resource decisions (Pinchot 1972). As a result, local efforts at compromise are often typecast as being "antibear" or "antiuse," depending upon the viewer´s perspective and the nature of the issues involved (Simpson 1985a,b; Ruemenapp 1985.)

CONCLUSION

In the end, as with all public undertakings, the grizzly will not be saved by just those with noble purpose or determined commitment to the cause (Kennedy 1964; Symms 1985). Idealism, laws, fines, restrictions, or changes in land use won´t do it either, but some will be needed. Nor will members of Congress, forest rangers, game wardens, committees, or bureaucrats pull it off, although they too will help. Recovery will be accomplished by ordinary people who live and work in and near grizzly country and who are comfortable with where the line is drawn between bear priorities and human priorities (Montana Department of Fish, Wildlife and Parks 1985). When that comfort level is reached, the political habitat will correspond to the biological.

Senator Steve Symms (1985) of Idaho recently summarized the recovery challenge facing managers. He said:

> The protection of endangered species cannot be carried to a point where it conflicts with the demands of society. We must remember that our national goal to protect these species was established at the request of society, and was not a self-perpetuating objective born in the bowels of a government bureaucracy. Habitat management policies that ignore the needs of individual members of society are therefore counterproductive, and in the end, may only serve to weaken the public´s desire to fulfill this important stewardship.

Due to the intense interest, inspired research, and commitment of many individuals and organizations, managers now have better information and more refined techniques at their disposal. This, coupled with a wealth of public interest and concern can ensure the recovery of grizzly if used intelligently and with discretion. Some have suggested that recovery of the grizzly is an ethical "test" of society. That is not wholly true. A bigger challenge is for managers and researchers to use our scientific, social and political resources to build strong local consensus for bear management in all parts of every grizzly bear ecosystem. To do that, we will have to ensure that every National Forest and National Park user, each rancher and landowner, and the involved Senators, Congresspersons or Representatives, State legislators, county commissioners, concessionaires, and chambers of commerce agree that the course of action is both sensible and fair.

REFERENCES

Boyd, Stan. Grizzlies and sheep and people. Idaho Wool Growers Bulletin. October 1984.

Burns, John E. Targhee National Forest grizzly bear-grazing controversy. 1981a. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Burns, John E. [Letter to Forest Supervisor, Bridger-Teton National Forest]. 1981b December 31. 1 leaf. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Burns, John E. [Letter to Regional Forester, Intermountain Region]. 1982a February 23. 1 leaf. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Burns, John E. [Letter to Thomas McNamee]. 1982b April 5. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Burns, John E. [Letter to Bill Enget]. 1984a. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Burns, John E. [Letter to Bill Enget]. 1984b July 13. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Burns, John E. [Letter to Regional Forester, Intermountain Region]. 1984c March 19. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Burns, John E. [Letter to Ray Rigby]. 1984d August 14. 3 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Burns, John E. [Letter to Senator Steve Symms]. 1984e September 18. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Burns, John E. [Letter to Regional Forester]. 1984f December 4. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Buterbaugh, Galen L. Minutes of October 31-November 1, 1984, IGBC meeting, Denver. 1985. Unpublished paper on file at U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Campbell, Cathryn. Federal protection of endangered species: a policy of overkill? Journal of Environmental Law. 3: 247-274; 1983.

Coston, Tom. [Letter to All Interagency Grizzly Bear Committee Members]. 1984 December 13. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Griffel, David. Amendment to 1975 Jorgensen-Allen grizzly bear study. 1976a. Unpublished report on file at U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Griffel, David. Bear-livestock interactions of the Targhee National Forest. 1976b. Unpublished report on file at U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Hackett, David. Grizzly decline linked to park policy. Jackson Hole [WY] Guide. 1983 November 23; Sect. A: 3,20.

Idaho Wool Growers Bulletin. Grizzly Bear panel sparks debate. December 1984: 5.

Johnson, Orlo. [Letter to District Rangers]. 1976 October 28. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Jorgensen, Carole. Bear-livestock interactions, Targhee National Forest. Missoula, MT: University of Montana; 1979. 150 p. M.S. thesis.

Kennedy, John F. Profiles in courage. New York: Harper & Row; 1964. 287 p.

Knight, Richard R.; Judd, Steven L. Grizzly Bears that kill livestock. In: Proceedings, International Conference Bear Research Management. 5:186-190; 1980.

Koon, Kathy. Is rancher's problem humans or bears? Idaho Falls Post-Register. 1984 July 25; Sect. D: 1.

Lee, Phillip L. Biological evaluation of man/grizzly bear conflicts related to sheep grazing in essential grizzly bear habitat on the Targhee National Forest. 1981. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Marcoux, Ron. Statement of Montana and International Association of Fish and Wildlife Agencies before the Subcommittee on Fisheries and Wildlife Conservation and the Environment, House Committee on Merchant Marine and Fisheries, on endangered species act reauthorization. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1985. 2 p.

Matejko, George; Franklin, Barbara. Summary of the Grizzly Bear No. 38/sheep incident. 1983. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Matejko, George; Franklin, Barbara. Summary of the grizzly/human incidents of August 23 to September 4, 1984, Island Park District, Targhee National Forest. 1984. Unpublished report on file at U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

McClure, James A.; Symms, Steve. [United States Senators]. [Letter to Regional Forester Stan Tixier]. 1983 October 20. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

McNamee, Thomas. The grizzly bear. New York: Alfred A. Knopf; 1984. 308 p.

Mehrhoff, L. A. [Letter to Jeff M. Sirmon]. 1981 July 13. 7 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Mehrhoff, L. A. [Letter to L. Kent Mays, Jr.]. 1982 May 25. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Melnykovych, Andrew. Officials brace for more incidents. Casper [WY] Star-Tribune. 1985 March 4; Sect. A: 1,12.

Montana Department of Fish, Wildlife and Parks. Perspective on the grizzly bear and the endangered species act. Helena, MT; 1985. 12 p.

National Parks Advisory Board, Wildlife Committee. The great bear in our parks. 1985. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

New York Times. Ranchers resist proposal to restore wolves. 1985 February 19.

Ogden [UT] Standard-Examiner. Grizzly recovery program meets with opposition. 1984 June 3.

Orme, Mark. Summary of grizzly statistics for 1980-1984. 1984 unpublished data update on file at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Orme, Mark L.; Williams, Robert G. Coordinating livestock and timber management with needs of the grizzly bear in Situation 1 habitat on the Targhee National Forest. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; [in preparation].

Pinchot, Gifford. Breaking new ground. Seattle: University of Washington Press; 1972. 522 p.

Rigby, Ray W. [Letter to Senator Steve Symms]. 1984 September 4. 1 leaf. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

Roberts, Paul H. Hoof prints on forest ranges. San Antonio: Naylor Company; 1963. 151 p.

Ruemenapp, Marie. Co-existing with a killer. National Wool Grower. February 1985: 8-11.

Siddoway, James [Chairman, Fremont County Commissioners]. [Letter to Idaho Senators and Representatives]. 1983 November 15. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Simpson, Alan K., United States Senator. [Letter to W. Donald Dexter]. 1985 January 16. 3 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Simpson, Alan K. [United States Senator]. [Letter to Editor, Jackson Hole Guide]. 1985 March 19. 2 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Snodgrass, Bill. Public should have priority over bears. Casper [WY] Star-Tribune; 1984 May 25.

Symms, Steve [United States Senator]. [Letter to author]. 1985 April 3. 3 leaves. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Tixier, Stan [Regional Forester]. [Letter to Senator James McClure]. 1984a February 3. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

Tixier, Stan [Regional Forester]. [Letter to Senator James McClure]. 1984b March 26. Located at: U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID; 2600 files.

U.S. Department of Agriculture, Forest Service. Guidelines for management involving grizzly bears in the greater Yellowstone area. Rocky Mountain Regional Office, Denver, CO; 1979.

U.S. Department of Agriculture, Forest Service. Proposed land management plan for the Targhee National Forest. St. Anthony, ID; 1981.

U.S. Department of the Interior, Fish and Wildlife Service. Grizzly bear recovery plan. Washington, DC; 1982. 195 p.

U.S. Department of the Interior, National Park Service. National Park Service to prepare environmental impact statement on Fishing Bridge: News release. Yellowstone National Park, WY; 1985 March 14.

U.S. Laws, Statutes, etc.; Public Law 98-473. Continuing Appropriations Act of 1985; Interior and Related Agencies, Section 316, Title III.

HABITAT RESEARCH NEEDS FOR GRIZZLY BEAR RECOVERY

Christopher Servheen

ABSTRACT: Past grizzly bear habitat research in the contiguous 48 States includes a significant amount of information on the general biology and habitat needs of the species in the Yellowstone and northern Continental Divide ecosystems. Continued work on general biology and habitat needs is continuing in the Cabinet/Yaak and Selkirk ecosystems, and work is planned in the Selway/Bitterroot and North Cascades ecosystems. Research emphasis has now shifted from site-specific, general biology studies to topical studies directed at the effects of human-related activities on grizzly bear behavior and habitat use. Future research is needed on the concept of carrying capacity, habitat effectiveness, the predictability of annual and long-term food variation within and between ecosystems, the independence of ecosystems from environmental randomness, the effects of human activity on movement patterns to prevent habitat fragmentation, and the development of a predictive habitat use model.

INTRODUCTION

The survival of the grizzly bear depends upon many factors: habitat preservation and management, minimizing excessive human-induced mortality, and citizens' understanding about what is necessary to preserve the species. Habitat management depends upon specific information about what the grizzly bear requires to survive and the effects of human activities on the availability and use of these necessities.

Intensive habitat research on the grizzly bear began in the lower 48 States with the work of Frank and John Craighead in the Yellowstone area between 1959 and 1970. When the grizzly was declared a threatened species in 1975, research on grizzly bear biology and habitat needs expanded through almost all areas of remaining habitat in the lower 48 States. Most efforts on habitat research since 1975 have focused on basic habitat use parameters and food habits of the species in the varied habitats in the lower 48 States.

Habitat use and preference information and food habits by season have been analyzed in the Yellowstone Ecosystem using habitat type base maps and more than 3,900 locations gathered using radio-collared bears since 1975 (Knight and others 1984). This analysis has produced a clear picture of grizzly bear food habits and habitat use patterns in this ecosystem.

In the northern Continental Divide grizzly bear ecosystem, habitat preference information has been determined in several study areas (Servheen and Lee 1979; Mace and Jonkel 1980b; Schallenberger and Jonkel 1979, 1980; Zager 1980; Aune and Stivers 1981, 1982, 1983; Servheen 1983; McLellan and Mace 1985) by comparing habitat use from radio locations to habitat availability within the home range of radio-collared animals (Marcum and Loftsgaarden 1980). Several of these studies on the basic habitat requirements of the grizzly in different areas of this ecosystem are continuing.

Grizzly bear habitat in the Cabinet/Yaak ecosystem has been intensively mapped as part of a habitat management program by the Kootenai National Forest (Christensen and Madel 1982). Using this habitat mapping as a foundation, the ongoing grizzly studies in the Cabinet/Yaak ecosystem (Kasworm 1984, 1985) are continuing to gather basic information of the habitat use patterns and distribution of this small population.

The Selkirk ecosystem in Idaho and Washington has been surveyed for grizzly habitat suitability (Zager 1983), and the area is being mapped as part of the habitat management program by the Idaho Panhandle National Forests. Basic information on habitat use and distribution in this area was gathered as part of a master's study at the University of Idaho by Jon Almack (1985) and further work is planned along the Canada-United States border in 1986.

Habitat in the North Cascades ecosystem has not been mapped or surveyed, although Sullivan (1984) completed a survey on the historical distribution of the grizzly and the validity of recent sightings in this area. A portion of the Selway-Bitterroot ecosystem has been surveyed for grizzly bear habitat suitability (Scaggs 1979) and further work that delineates important habitats and determines the suitability of present habitats to support bears will begin in 1985.

Thus, considerable information on the basic biology and habitat needs of the grizzly has been gathered since 1975 in four of the six ecosystems where the grizzly remains. Ten years of research have produced considerable baseline information in the Yellowstone and northern Continental Divide ecosystems on habitat use patterns, food habits, and movements. Less information is available in the remaining four ecosystems, and work on basic grizzly bear biology will continue in these areas.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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Information on basic biology and habitat needs has been developed through site-specific studies on the biology of the grizzly population in the area of interest. Using site-specific data, land management agencies have been able to develop management guidelines for important seasonal habitats. Such guidelines have been the basis for managing road and trail closures in important seasonal range; limiting disturbances in denning areas; establishing helicopter flight lines and seismic exploration guidelines to avoid important seasonal use areas; and timber harvest stipulations in grizzly habitat.

CURRENT EFFORTS

Since the approval of the Grizzly Bear Recovery Plan in 1981 and the implementation of the Interagency Grizzly Bear Committee research planning effort starting in 1983, the direction of research on the grizzly bear in the lower 48 States has shifted. This was due in part to the recognition that available information on the general biology and habitat use of the grizzly in the Yellowstone and northern Continental Divide ecosystems was adequate to make general management decisions for the species in these areas. It was also recognized that baseline information was still necessary from the other four ecosystems.

The shift of research direction since 1983 has been away from the site-specific, general bear biology studies of the past to topical studies focusing on the effects of certain human activities on the behavior and habitat use of the grizzly bear. These topical studies are designed to supply information on how bears relate to specific activities so these can be more effectively managed. This information is necessary as management becomes ever more fine-tuned and managers are called upon to specify why certain management actions are necessary and whether these actions improve conditions for the species. This specific information on the effects of certain human activities is necessary if the public is to be convinced that management decisions are legitimate and necessary. In addition, the cumulative effects analysis process requires specific information on the influence zones of certain human activities such as recreational trail use, roads, backcountry camps, and helicopter overflights so these zones can be incorporated into the new computer-based cumulative effects analysis process.

Increasing natural resource and recreation demands in occupied grizzly bear habitat create disturbances which can take two forms:

1. Ecological disturbance changes the structure of the physical landscape and results from such activities as timber harvest, fire, petroleum development, housing subdivisions, developed campgrounds, or livestock grazing. Ecological disturbance affects the presence of resources and can be permanent or at least long-lasting. Whether an ecological disturbance is a positive or negative factor in grizzly bear habitat depends on its application.

2. Behavioral disturbance and loss of solitude results from such activities as helicopter use, recreation, petroleum exploration, or road use. Behavioral disturbance changes the use and availability of existing resources without changing their character and is usually temporary.

Examples of ecological disturbance studies in the lower 48 States include Zager (1980) on the effects of wildfire and timber harvest and Aune and Stivers (1981, 1982, 1983) on livestock grazing and oil and gas development. Examples of behavioral disturbance studies include Mace and Jonkel (1980a) on timber harvest, McLellan and Mace (1985) on the effects of roads and helicopters, and Schleyer and others (1984) on the effects of backcountry recreation. The majority of research on ecological and behavioral disturbance in the lower 48 States focuses on oil and gas exploration and development, backcountry recreation, and roads and motorized road use.

If the effect of habitat disturbance is most profound in pristine areas, documentation of this fact is important to management of much of the remaining grizzly bear habitat in the lower 48 States. The increased demand for oil and gas exploration and development is a prime example of a human disturbance that will soon be introduced into most of occupied grizzly habitat outside national parks and some wilderness areas (Schallenberger 1980). Ecological and behavioral disturbance will continue to increase in grizzly habitat. Because much occupied grizzly range is multiple-use land, exclusion of human activity is not possible or desirable. Successfully minimizing the negative effects of human disturbance will depend upon management decisions based on sound information about the effects of both ecological and behavioral disturbance.

FUTURE NEEDS

Certain questions concerning habitat remain to be addressed for the successful recovery and future management of the grizzly bear in the lower 48 States. In general, these questions involve ecological principles and the application of the concepts of conservation biology to the management of the species.

We must apply the concept of carrying capacity to the grizzly bear if recovery targets are to be realistic and achievable, but because the grizzly bear is an opportunistic omnivore that uses diverse foods that vary annually, it is difficult to apply this concept. It may be necessary to determine carrying capacity through long-term observation of annual food resource changes and the subsequent responses of bear populations. There has been little thought given to this concept for the grizzly to date, and its solution may require careful integration of ecological, environmental, and social factors for the species.

Although there is considerable speculation about the usefulness of the carrying capacity idea (Caughley 1979), the need to know how many bears

can exist on a given piece of occupied habitat is critical to the management strategies necessary for the survival of the species. This is especially important because grizzly territory will be limited to the areas occupied when the bear was declared threatened in 1975.

The concept of minimum viable population size (MVP) for the grizzly bear was pioneered by Mark Shaffer (1983). This concept underlies the minimum recovery targets of the Grizzly Bear Recovery Plan (U.S. Department of the Interior 1982). Applications of this concept to the grizzly bear are based on the genetic and demographic considerations of population size. Once the demographic and genetic considerations are met, a population level can be projected which has a certain probability of survival over a certain time period. This population level can then be the target of recovery management. The application of the concept is limited, however, by the habitat available for grizzly population recovery and the carrying capacity of that habitat. To legitimately apply recovery targets, the minimum viable population size must be applied to the available habitat and the carrying capacity of that habitat must be assessed to determine if the habitat can support the minimum population size. Thus, to properly apply MVP, we must have an estimate of the carrying capacity for each ecosystem.

The concept of carrying capacity is closely related to the idea of habitat effectiveness. In the past, habitat effectiveness has been considered the availability of the habitat to the bears in the area or the areas free from human influence. Habitat effectiveness ratings have been based on the relationship between available undisturbed habitat and the seasonal habitat requirements of the species. A uniform definition and application of this term is needed, especially as the cumulative effects analysis process is applied to all occupied grizzly bear habitat.

There is a need for uniform and standardized data collection on all habitat research within and between ecosystems. With different research projects in different areas, different habitat definitions frequently develop. These different definitions complicate the comparison of data between areas and frustrate management efforts to develop standardized management systems based on this habitat information.

The grizzly bear depends upon diverse food resources whose distribution and availability are often random. Examples are shrub fruits such as Vaccinium spp., whitebark pine (Pinus albicaulis) seeds, and carrion. An overall review and compilation of the annual changes in these foods' distribution and availability in each ecosystem is needed to assess carrying capacity and to predict the bear-human conflicts resulting from these variations.

The relationship of major food supply variations within and between ecosystems is not known, yet the independence of ecosystems with regard to these random events is important to successful management. To what extent variations are predictable according to weather or long-term cycles is a useful question for managers who must consider changes in bear food abundance and their effect on bear-human conflicts. If these patterns of food change were more predictable, bear and people management could attempt to mitigate their effects.

The relationship between habitat values and population limits has never been adequately described, but it seems reasonable to relate changes in habitat productivity to demographic parameters such as ability to survive, reproductive interval, implantation of blastocysts after females enter the den, and behavioral changes such as dispersal of subadults and changes in home range size. Determining the relationship between these demographic and behavioral parameters and specific habitat characteristics would make it easier to determine habitat-related limiting factors. This in turn would promote mitigation of the effects of these limitations and recognition of the factors influencing the rate of population recovery. Although we can now change certain grizzly bear habitat factors through timber harvest, prescribed fire, and planting certain food plants, there is insufficient information to demonstrate that these habitat components are the factors that limit populations.

The idea of habitat reserves has recently been suggested in British Columbia (Archibald 1983). These areas would provide refuge from most human-related causes of mortality. These reserves are projected to be high-production areas where populations reproduce at high rates. Subadult grizzlies from these areas could then populate the areas surrounding the reserves. Implementing this idea requires determining the habitat values and mix necessary to provide maximum production. In the lower 48 States, two possible reserves already exist--Glacier and Yellowstone National Parks. Further examination of the idea of habitat suitability and limiting factors will aid in the assessment of the reserve idea.

Preventing habitat fragmentation is also an important issue. Such fragmentation was a major factor in the elimination of the grizzly bear throughout much of the American West. It occurred when lands in occupied habitat were made unsuitable through habitat alteration or where the grizzly was not tolerated. This fragmentation isolated small insular populations which then became more susceptible to random habitat factors and to killing by humans. As the human use of grizzly bear habitat continues, suitable movement corridors within existing habitat must be maintained. The remaining ecosystems are fragments of the former range of the species; further fragmentation will seriously threaten the potential for the recovery and survival of the species.

Maintaining entire ecosystems requires continuing the current integration of grizzly populations that span the United States-Canada border. At least four of the six remaining ecosystems in the contiguous United States share habitat and grizzly bear populations with Canada. The northern Continental Divide ecosystem shares the

largest border with Canada, and this connection may be the most imperiled. There is considerable timber harvest, road building, and oil and gas exploration and development on both sides of the border, and a major open-pit coal mine immediately north of the border is planned. We need to know the tolerance of bears for such human activities, the inhibitions to movement posed by such activities, and the changes in survival rates of bears that live in or move through such activity areas. The cumulative effects analysis process will allow us to realize the compounding factors that may exist along potential fragmentation lines where many activities threaten movement. To adequately manage these activities, we need to know what levels of development and activity influence movement patterns and how human activity influences dispersal patterns of subadults. These questions must be answered if we are to prevent further fragmentation of the remaining habitat.

Several grizzly bear habitat mapping methods have been developed with various levels of resolution (Servheen and Lee 1979; Zager 1980; Christensen and Madel 1982; Craighead and others 1982). This information will be used in land management planning and in implementing the cumulative effects analysis process. These methods need to be evaluated as elements of a conceptual model to predict grizzly bear habitat selection as proposed by Lyon (1985). If a mapping system can be used to predict grizzly bear habitat use, it could be standardized and applied to all occupied habitat.

Preliminary plans have been made to test existing mapping methods as part of a predictive habitat use model.

Continued progress in habitat research will depend upon coordination and cooperation between all agencies and support of those projects which are carefully designed to produce information needed to meet the management needs for recovery of the grizzly bear. Continued interagency coordination through the Interagency Grizzly Bear Committee will assure support for those projects that have been productive and successful.

REFERENCES

Almack, J. An evaluation of grizzly bear habitat in the Selkirk Mountains of North Idaho. Moscow, ID: University of Idaho; 1985. 87 p. M. S. Thesis.

Archibald, W. R. Problem analysis: grizzly bears and coastal development with particular reference to intensive forestry. Fish and Wildlife Bulletin No. B-26. Victoria, British Columbia: Ministry of Environment, Wildlife Branch; 1983. 20 p.

Aune,K.; Stivers, T. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife, and Parks; 1981. 50 p.

Aune, K.; Stivers, T. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1982. 143 p.

Aune, K.; Stivers, T. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1983. 180 p.

Caughley, G. What is this thing called carrying capacity? In: Boyce, M. A.; Hayden-Wing, L. D., eds. North American elk: ecology, behavior and management. Madison, WI: University of Wisconsin; 1979: 2-12.

Christensen, A. C.; Madel, M. J. Cumulative effects analysis process; grizzly bear habitat componant mapping. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1982. 61 p.

Craighead, J. J.; Sumner, J.; Scaggs. G. B. A definitive system for the analysis of grizzly bear habitat and other wilderness resources. Missoula, MT: Wildlife-Wildlands Institute, University of Montana Foundation, University of Montana; 1982. 279 p.

Kasworm, W. Cabinet Mountains grizzly bear study annual report, June-December 1983. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1984. 50 p.

Kasworm, W. Cabinet Mountains grizzly bear study 1984 annual progress report. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1985. 81 p.

Knight, R. R.; Mattson, D. J.; Blanchard, B. M. Movements and habitat use of the Yellowstone grizzly bear. Bozeman, MT: Report of the Interagency Grizzly Bear Study Team; 1984. 177 p.

Lyon, L. Jack. A discriminant function analysis of habitat selections. Presented at the annual meeting of the Northwest Section of the Wildlife Society; 1985 April 2-5; 1985. 20 p. Unpublished.

Mace, R.; Jonkel, C. Grizzly bear response to habitat disturbance. In: Jonkel, C., ed. Border Grizzly Project, Annual Report No. 5. Missoula, MT: University of Montana; 1980a: 70-98.

Mace, R.; Jonkel, C. Seasonal food habits of grizzly bears in northwestern Montana. In: Jonkel, C., ed. Border Grizzly Project, Annual Report No. 5. Missoula, MT: University of Montana; 1980b: 49-69.

Marcum, C. L.; Loftsgaarden, D. O. A nonparametric technique for studying use vs. availability of environmental components. Journal of Wildlife Management. 44: 963-968, 1980.

McLellan, Bruce N.; Mace, Rick D. Behavior of grizzly bears in response to roads, seismic activity and people. Cranbrook, B.C.: Canadian Border Grizzly Project; 1985 Preliminary Report. 52 p.

Scaggs, G. B. Vegetation description of potential grizzly bear habitat in the Selway-Bitterroot area, Montana and Idaho. Missoula, MT: University of Montana; 1979. 148 p. M.S. thesis.

Schallenberger, A. Review of oil and gas exploitation impacts on grizzly bears. In: Martinka, C. J.; McArthur, K. L., eds. Bears - their biology and management, Bear Biology Association Conference Series No. 3, Kalispell, MT: 1980: 271.

Schallenberger, A.; Jonkel, C. Rocky Mountain East Front grizzly studies, 1978, Annual Report Border Grizzly Project. Missoula, MT: University of Montana, School of Forestry; 1979. 207 p.

Schallenberger, A. Rocky Mountain East Front grizzly studies, 1979. Border Grizzly Project Special Report No. 39. Missoula, MT: University of Montana, School of Forestry; 1980. 207 p.

Schleyer, B. O.; Jonkel, J. J.; Rhoades, K. G.; Dunbar, D. M. The effects of nonmotorized recreation on grizzly bear behavior and habitat use. Bozeman, MT: Interagency Grizzly Bear Study Team; 1984; Preliminary Report. 83 p.

Servheen, C.; Lee, L. C. Mission Mountains grizzly bear studies; an interim report, 1976-78. Missoula, MT: University of Montana, School of Forestry; 1979. 299 p.

Servheen, C. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. Journal of Wildlife Management, 47: 1026-1035; 1983.

Shaffer, M. L. Determining minimum viable population sizes for the grizzly bear. Durham, North Carolina: Duke University; 1978. 190 p. Ph.D. dissertation.

Sullivan, P. T. A preliminary study of historic and recent reports of grizzly bears, Ursus arctos in the North Cascades area of Washington. 1983. Unpublished report on file at: Olympia, WA: Washington Department of Game. 31 p.

U.S. Department of the Interior. Grizzly bear recovery plan. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service; 1982. 195 p.

Zager, P. E. Influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Missoula, MT: University of Montana, Department of Botany; 1980. 131 p. Ph.D. dissertation.

Zager, P. E. Grizzly bears in Idaho's Selkirk Mountains: an update. Northwest Science. 57: 229-309, 1983.

GRIZZLY BEAR HABITAT RESEARCH IN GLACIER NATIONAL PARK, MONTANA

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ABSTRACT: Grizzly bear habitat research began in 1967 and is continuing in Glacier National Park, MT. Direct observations and fecal analysis revealed a relatively definable pattern of habitat use by the bears. Habitat data were subsequently used to develop management models and explore the relationship between grizzlies and park visitors. Current research strategy is based on the concept that humans are an integral component of grizzly bear habitat. A geographic information system is being developed to assist in the application of habitat data. In addition, the behavioral response of grizzlies to annual changes in food production is being studied. Management that addresses bears, humans, and their habitat as a system is proposed.

INTRODUCTION

Grizzly bears (Ursus arctos) and paleolithic humans (Homo sapiens) are relatively recent additions to the megafauna of North America. Both species emigrated eastward from Eurasia and colonized Beringia during the Wisconsin glacial period. Humans dispersed toward southern continental areas early in the glacial period, and grizzlies followed after the continental ice sheet melted some 12,000 years ago. Except for that period between emigrations, grizzlies and humans have coexisted for millenia in holarctic habitats.

The advent of modern humans and their sophisticated weapons was significant to grizzly bear evolution. In Europe, exploitive pressures began nearly a thousand years ago and reduced bear population numbers and distribution substantially (Cowan 1972). Similar impacts occurred more recently in North America and were measurably more dramatic. The species currently occupies less than half of its historic range, and its status is tenuous south of Canada. On both continents, grizzly demographic responses have been accompanied by increasing shyness, a behavioral trait with distinct survival value.

Large national parks provided the first sanctuaries for grizzlies on the southern edge of their shrinking range in North America. Parks initially protected remnant populations that persisted in spite of intense exploitation. Subsequently park management goals included restoring grizzly bear numbers to those that existed under pristine conditions. This effort was unique in the historic relationship between grizzlies and humans in that it largely eliminated the demographic and behavioral consequences of bear mortality from hunting and other human-related causes. Most likely, this policy is at least partly responsible for the dynamic history of grizzlies and humans in the parks.

The relationship between grizzly bears and modern humans is reflected in the history of Glacier National Park, MT (Martinka 1976a). The bear population appears to have been heavily exploited, and numbers were low when the Park was established in 1910. Recovery took at least 50 years; only in recent decades have natural limits to population growth been approached (Keating 1983). Human use of the Park gradually increased over the same period and reached two million visits in 1983. Conflicts between the two species also increased, and there is now evidence that the incidence of human injuries and deaths is accelerating (Martinka 1982).

In 1967, grizzlies killed two campers in separate backcountry campsites in Glacier National Park. Their deaths prompted a critical evaluation of the relationship between grizzly bears and Park visitors. Not surprisingly, it was quickly discovered that little was known about either species and how they fit into the ecological matrix of the Park. However, it was generally agreed that both had a legitimate place and that conflict detracted from the potential for successful Park management. These conclusions inspired a scientific research program designed to gather information and explore means for separating the species and reducing conflicts. A first step toward that goal was to study the habitat in which conflict occurred, and thus grizzly habitat formed an important element of initial study design. This paper presents a synopsis of grizzly bear habitat research findings, describes current habitat research efforts, and attempts a conceptual synthesis of potential management applications in Glacier National Park.

COMPLETED HABITAT STUDIES

Originally grizzly bear habitat studies were descriptive and used traditional field observational techniques. Bear sightings were recorded and fecal samples collected during extensive coverage of the Park trail system. Although individual observers made few sightings, sample size was enhanced through a data base compiled from verified sightings from all sources. Sampling bias resulted from unquantified observer effort, variable reporting rates, observer confinement to roads and trails, and poor bear observability due to rugged topography and forest cover. However, habitat relationships were generally consistent with those

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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determined using more sophisticated field technology such as radio telemetry.

Results of the early Park studies suggested that grizzlies were well adapted to postglacial mountain habitats (Martinka 1972, 1976a). Each of the major Park plant communities was used by the bears at some time during the season of activity from May through October. Although the bears frequented coniferous forests, they apparently preferred treeless habitats. Grasslands and alpine tundra provided open habitats; wildfire and snowslides created shrublands within the extensive coniferous forest zone. The distribution of grizzlies shifted in response to favored foods which included succulent herbs and nutritious fruits. Bears were most consistently associated with habitat diversity and abundant moisture.

Extensive field investigations identified two seasonal bear concentrations that were subsequently intensively evaluated. In 1969-70, Shaffer (1971) studied a late summer gathering on the Apgar Mountains. Results supported earlier observations that ripening huckleberries (Vaccinium spp.) were an important attraction to grizzly and black bears (Ursus americanus). Findings also suggested that niche separation occurred between the two species. From 1972 to 1975, Singer (1978) studied a spring concentration of grizzlies along the North Fork Flathead River. Wet meadows and alluvial seres were important habitats that provided rhizomatous grasses, succulent forbs, roots, and tubers. The timing of melting snow appeared to influence the intensity of the spring gathering in that greater numbers were present when snowmelt was late. Both studies demonstrated that seasonal coalescence was an important element of grizzly bear habitat relationships in the Park.

A series of grizzly bear incidents from 1974 to 1976 prompted an assessment of the field research program. It was apparent that knowledge about habitat relationships was improving but questions about the data's usefulness remained unanswered. To answer them, a series of four studies from 1975 to 1980 examined how people were distributed in grizzly bear habitat. Each study related human activities to existing habitat information.

From 1974 to 1977, studies focused on the backcountry travel patterns of visitors using the northern half of the Park (Stuart 1977a, 1977b, 1978). Stuart developed bear contact indexes from sighting data, trail characteristics, and habitat distribution and then constructed models to demonstrate the various management options available for altering the rate of contacts between grizzlies and visitors. The study accurately predicted that increasing backcountry use would lead to an even greater increase in the contact rate (Martinka 1982). In addition, a shift in management to prevent dangerous contacts (females with young) was proposed.

The wilderness travel project was accompanied by a backcountry campsite evaluation in 1975 (Merrill 1978). Ecological and sociological factors associated with damaged property and human injuries were compiled for 50 black and grizzly bear incidents. An unexpectedly high number occurred in deteriorated campsites in mature forests that were near developments and that had large party limits and good fishing nearby. Once again, niche differences were apparent in that a greater proportion of grizzly incidents occurred in the alpine zone and open canopy forests. Extensive changes have been made in campsite location since the study was completed.

In 1977, the research emphasis returned to grizzlies; one project explored food production as a means for predicting habitat use (Riggs and Armour 1981). Field effort focused on riparian habitats, involved intensive vegetation sampling, and used a radio-tagged bear to measure habitat preference. Because selection patterns were consistent, the investigators believed that contact with the bear was avoidable. Unfortunately, the sample size of one radio-tagged bear precluded formulation of conclusions. In spite of this, it seemed reasonable to propose that changing the habitat use patterns of Park visitors could decrease the frequency of dangerous encounters.

Increasing confrontation rates provided incentive for a more detailed assessment of grizzly bear behavior toward people in 1980-81 (Jope 1982, 1985). The study examined habituation and its relationship to conflicts with humans. Results pointed to the importance of habituation as a process that allowed bears to exploit habitats being used by Park visitors. In addition, ancillary data revealed year-to-year changes in bear distribution that likely reflected geographic flux in habitat productivity. These conclusions emphasized the dynamic nature of grizzly bear habitat relationships as well as the potential for change with expanding human use.

CURRENT HABITAT STUDIES

Recent research has focused on habitat relationships as a key to understanding bear behavior and its influence on conflicts between bears and humans. The unique nature of bears ties them closely to habitat configuration and productivity. An inefficient digestive tract generalized for omnivorous habits combined with the demands of hibernation require that bears consume large amounts of food during their six months of activity each year. Because bears devote much of their energy budget to foraging, their distribution and activities should reflect environmental variation as it affects vegetation communities and other food supplies. Learning more about how bears adapt to fluctuations in their food resource may help predict behavior changes useful to management of bears and people.

This research direction was given impetus by another year of unusually severe conflict between grizzlies and humans in Glacier National Park. In 1980, three campers were killed in two separate grizzly bear attacks. We hypothesized that low huckleberry production in 1979 and 1980 and associated nutritional stress on bears triggered behavioral changes which increased the chance of dangerous encounters with people. This was compatible with previous studies which found that

forage productivity influenced grizzly bear habitat use (Riggs and Armour 1981; Jope 1982). Rogers (1976) and Picton (1978), among others, demonstrated the importance of climate and its effect on food availability to bear population parameters.

We began to test this hypothesis in 1982. The objectives were to expand understanding of seasonal food habits of bears throughout the Park, document annual fluctuations in the productivity of preferred bear foods, and examine the relationship between food availability and bear behavior (Kendall 1985b). Efforts thus far have been directed toward obtaining data on the first two objectives. Initial results have confirmed early food habits findings (Martinka 1972) and revealed dramatic fluctuations in productivity of huckleberries, a key bear food.

Results from the current food habits study corresponded closely with those reported for the 1967-71 period (Martinka 1972; Kendall 1985b). When these two data bases were combined they provided a representative picture of Park-wide bear food habits (table 1). Several generalities were evident from preliminary analyses. The dominant bear foods were grasses and sedges, umbels (notably *Heracleum lanatum* and *Angelica* spp.), and huckleberries. Animal protein, roots, and bulbs apparently played only a minor role in bear nutrition in Glacier National Park. Although use of grasses, sedges, and succulent forbs remained fairly constant each year, consumption of huckleberries and other fruits varied. These patterns reflected food availability and subsequent habitat use. In a typical year, huckleberries from high-elevation shrubfields were the principal food of late summer and fall. When huckleberry crops were poor, bears increasingly moved to low-elevation riparian areas to feed on hawthorn (*Crataegus douglasi*) berries and other foods.

Huckleberries became the primary focus of food availability studies because production appeared to vary more than in other important bear foods. Work conducted since 1982 has documented large year-to-year changes in huckleberries available to bears (Kendall 1985b). In 1983 and 1984, berry production was approximately 35 percent of the previous year; this was an 88 percent decline in huckleberry crops in a three-year period. This work also produced convincing evidence that huckleberry production could be regionally synchronous. The decreases in production were nearly ubiquitous throughout the park, with declines in over 90 percent of the sites studied in both of the past two years. The next step should be to determine if berry production levels change bear-foraging activity and contribute to bear-human interactions.

Another variable, berry phenology, was also found to influence bear distribution. Aerial surveys designed to monitor grizzly bear population trends have taken advantage of bear concentrations in the shrubfields of the Apgar Mountains (Kendall 1983, 1984, 1985). Bears move into this area as huckleberries mature (Shaffer 1971). Variation in ripening dates and in numbers of bears sighted suggests that knowledge of the ripening process is an effective tool for predicting when bears congregate each year (Kendall 1985a). Linking flight schedules with berry phenology was considered essential for biologically significant year-to-year consistency in surveys designed to track long-term population trends.

Considering both bears and people as elements of the park ecosystem set the stage for further research. In a recent effort to describe the relationship between grizzly bear and human use of the Park (Baldwin and others 1985), researchers mapped grizzly habitat and backcountry visitor use in a portion of the Park. By overlaying these two data bases, the potential for conflict could be evaluated.

Grizzly habitat was mapped in the Two Medicine area of the Park using Glacier's Geographic Information System (GIS) (Butterfield and Key, this proceedings). The GIS classified vegetation by combining Landsat spectral data with digital terrain information. Vegetation classes were grouped into units representing vegetation associations exploited seasonally by grizzly bears. The groupings were based on habitat and food habits information for Glacier National Park (Martinka 1976a; Kendall 1985b) and extrapolation from other studies. Ground verification indicated that the technique provided detailed information on forested areas and habitat mosaics but did not effectively distinguish among moist, shrub-dominated sites. It was felt that the incorporation of ancillary data, such as burn perimeters, snowslide reaches, and riparian corridors would solve this problem allowing the system to provide general but accurate grizzly bear habitat information.

Visitor use patterns of the same area were mapped using a trailhead survey, which provided information on backcountry visitor activities and their use of the Park in space and time (Baldwin and others in preparation). The visitor mapping technique was an effective tool that could be adapted to a variety of situations and information needs. Integration of grizzly habitat and human use patterns revealed high numbers of hikers concentrated in the highest quality bear habitat. However, potential conflicts were minimized because most human use occurred during periods when bear use was not likely. It was concluded that knowledge of grizzly bear habitat needs has limited usefulness to Park managers without understanding the role of humans in that system.

CONCLUSIONS

Habitat studies have been an important part of the grizzly bear research program in Glacier National Park, and the knowledge contributed by them has improved our understanding of the ecological niche of grizzlies in the park environment. Study results also pointed to the likelihood that humans occupied an overlapping niche and competed with the bears for available habitat. It therefore seems appropriate that bears, humans, and their habitat be managed as a system. Field application of this concept requires that habitat be treated as a resource shared by the two dependent species and that management decisions be based on credible habitat information.

Table 1.--Seasonal food habits of bears in Glacier National Park, MT, from analysis of 943 scats sampled 1967-71 and 1982-84

Food Item		Percent frequency and volume[1] Apr.-June (N = 294)		July-Aug. (N = 304)		Sept.-Oct. (N = 345)	
Grass, sedge, rush							
	Total	55	40	45	17	40	21
Herbaceous material							
Angelica spp.		2	1	8	6	1	1
Heracleum lanatum		20	16	17	14	4	3
Misc.[2] umbels		27	16	23	16	4	1
Misc. forbs		20	7	19	6	14	8
Equisetum spp.		24	9	11	4	2	1
Misc. other[3]		5	[4]T	7	T	5	T
	Total	71	49	63	46	26	13
Fruits							
Amelanchier alnifolia		0	0	6	3	10	5
Crataegus douglasii		0	0	2	1	14	13
Sorbus spp.		0	0	0	0	9	5
Vaccinium spp.		0	0	29	19	38	24
Misc. fruits		5	1	6	2	10	4
	Total	5	1	44	26	81	51
Animal							
Insects		21	1	28	4	4	1
Mammals		21	7	7	2	11	4
Fish		0	0	0	0	1	T
	Total	37	8	32	6	13	6
Roots, bulbs							
Erythronium grandiflorum		1	T	8	3	0	0
Hedysarum spp.		3	2	2	1	8	7
Misc. roots		1	T	1	T	3	2
	Total	4	3	10	4	11	9

1/ Total volume for each season may not equal 100 percent due to rounding error.

2/ Items comprising less than 5 percent volume during one season were grouped under the miscellaneous category.

3/ Shrubs, trees, and miscellaneous nonflowering plants.

4/ Less than 0.5 percent of scat volume.

REFERENCES

Baldwin, S. B.; Butterfield, B. R.; Wright, R. G.; Machlis, G. E. Habitat and visitor mapping in the Two Medicine area of Glacier National Park: combining information-gathering techniques. Moscow, ID; University of Idaho Cooperative Park Studies Unit; 1985. 110 p.

Cowan, I. M. The status and conservation of bears (Ursidae) of the world - 1970. In: Herrero, S., ed. Bears-their biology and management. International Union for the Conservation of Nature New Series 23: 221-231. 1972.

Jope, K. L. Interactions between grizzly bears and hikers in Glacier National Park, Montana. Corvallis, OR: Oregon State University; 1982. 62 p. M.S. thesis.

Jope, K. L. Implications of grizzly bear habituation to hikers. Wildl. Soc. Bull. 13: 32-37; 1985.

Keating, K. A. Trends in grizzly bear numbers and behavior (1910-1980) relative to sighting and confrontation rates in Glacier National Park, Montana. Glacier National Park Research Rep.; 1983. 44 p. Unpublished report.

Kendall, K. C. Grizzly bear population trend studies, Apgar Mountains, Glacier National Park. National Park Service Prog. Rep.; 1983. 19 p. Unpublished report.

Kendall, K. C. Grizzly bear population trend studies, Apgar Mountains, Glacier National Park. National Park Service Prog. Rep.; 1984. 37 p. Unpublished report.

Kendall, K. C. Grizzly bear population trend studies, Apgar Mountains, Glacier National Park. National Park Service Prog. Rep.; 1985a. 23 p. Unpublished report.

Kendall, K. C. Feeding ecology of grizzly bears in Glacier National Park, Montana. National Park Service Prog. Rep. [in preparation].

Martinka, C. J. Habitat relationships of grizzly bears in Glacier National Park, Montana. National Park Service Prog. Rep.; 1972. 19 p. Unpublished report.

Martinka, C. J. Ecological role and management of grizzly bears in Glacier National Park, Montana. In: Pelton, M. R.; Lentfer, J. W.; Folks, G. E. Jr., eds. Bears-their biology and management. International Union for the Conservation of Nature New Series 40: 147-156; 1976a.

Martinka, C. J. Grizzly bear population studies in Glacier National Park, Montana. National Park Service Symposium Ser. No. 1: 195-206. 1976b.

Martinka, C. J. Rationale and options for management in grizzly bear sanctuaries. Trans. North Am. Wildl. Nat. Resour. Conf. 47: 470-475; 1982.

Merrill, E. H. Bear depredations at backcountry campgrounds in Glacier National Park. Wildl. Soc. Bull. 6(3): 123-127; 1978.

Picton, H. D. Climate and reproduction of grizzly bears in Yellowstone National Park. Nature. 274: 888-889; 1978.

Riggs, R. A.; Armour, C. A hypothesis for predicting grizzly bear habitat use in spring floodplain habitat mosaics with special reference to reducing human-bear contact rates. National Park Service Compl. Rep.; 1981. 44 p. Unpublished report.

Rogers, L. Effects of mast and berry crop failures on survival, growth and reproductive success of black bears. Trans. North Am. Nat. Res. Wildl. Conf. 41: 431-437; 1976.

Shaffer, S. C. Some ecological relationships of black bears and grizzly bears of the Apgar Mountains in Glacier National Park, Montana. Missoula, MT: University of Montana; 134 p. M.S. thesis.

Singer, F. J. Seasonal concentrations of grizzly bears, North Fork of the Flathead River, Montana. Canadian Field Naturalist. 92(3): 283-286; 1978.

Stuart, T. W. Multi-objective analysis of wilderness travel in grizzly bear habitat using parametric linear programming. Berkeley, CA: University of California, Department of Forestry and Conservation; 1977a. 241 p. Ph.D. thesis.

Stuart, T. W. Exploration of optimal backcountry travel patterns in grizzly bear habitat. In: Martinka, C. J.; McArthur, K. L.; eds. Bears-their biology and management. Bear Biology Assoc. Conf. Series No. 3: 25-32; 1977b.

Stuart, T. W. Management models for human use of grizzly bear habitat. Trans. North Am. Wildl. Nat. Res. Conf. 43: 434-441; 1978.

USING GRIZZLY BEAR HABITAT INFORMATION TO REDUCE HUMAN-GRIZZLY BEAR CONFLICTS IN KOKANEE GLACIER AND VALHALLA PROVINCIAL PARKS, BC

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ABSTRACT: Valhalla Provincial Park and Kokanee Glacier Provincial Park, located in rugged southeastern British Columbia, support grizzly bear (Ursus arctos) populations and increasing human use. To better manage future conflicts between park visitors and grizzlies, information was gathered on grizzly bear habitat capability and utilization employing the transect method. This information was integrated into master planning (zoning), and the planning and management of trails, campsites, and mountain huts. Various examples and comparisons are given for both parks. The advantages and limitations of the transect method are discussed.

INTRODUCTION

The Province of British Columbia is larger than California, Oregon, and Washington combined. Most of British Columbia is sparsely populated and is still inhabited by grizzly bears, whose population has been estimated at 6,000 to 8,000 (Pearson 1977). About 4.5 percent of the land base is in provincial parks, many of which are in remote grizzly bear country that receives limited recreational use. Use of the wilderness is rapidly increasing, however, in some British Columbia parks, bringing more people in contact with grizzly bears. To reduce conflicts between people and grizzly bears, the British Columbia Ministry of Lands, Parks and Housing instituted a limited study on grizzly bear habitats in Valhalla Park in 1983 and in Kokanee Glacier Park in 1984.

Grizzly bear attacks most frequently occur when hikers encounter a grizzly bear suddenly or encounter a bear that has a history of feeding on people's food or garbage (Herrero 1985). Grizzly bears are most likely to be encountered at or near their natural feeding areas. Time budget studies show that grizzlies spend most of their time feeding and resting (Gebhard 1983; Stelmock 1981). Resting areas are usually near feeding areas. Thus an important means to decrease conflicts between people and grizzly bears is by locating trails, camping areas, and mountain huts away from important grizzly bear habitats. Grizzly-human encounters around camping areas and mountain huts are also related to food and garbage storage and to the proximity of these facilities to natural grizzly feeding areas.

The timing of park developments, budget constraints, or other factors often prohibit in-depth studies of grizzly bears and their habitats before development begins. In this paper we discuss the usefulness and limitations of a system for rapid field evaluation of grizzly bear habitats. We emphasize the identification of potential feeding areas and their use by grizzlies, although we also discuss denning sites, potential travel corridors, and other habitat parameters. We then show how we applied this information to master planning and location of trails, alpine huts and camping areas in two ecologically similar parks. In this context we compare the applicability of habitat information to an older park with previous development and master planning to a new park with little previous development where grizzly bear habitat information was incorporated into a new master plan.

STUDY AREAS

The study areas were Valhalla Provincial Park (494 km^2) and Kokanee Glacier Provincial Park (256 km^2). Both parks are located in the southern Selkirk Mountains in southeastern British Columbia, north of Nelson, BC. The parks are 15 km apart and are separated by a low valley and the large Slocan Lake.

Although the parks are ecologically similar, they differ substantially in their history, development, and accessibility. Kokanee Glacier Park was established in 1924. Much of the current network of roads and trails was developed by mining activities before and after the park was established. Kokanee is a Class "B" park which allows limited commercial activities (logging and mining), although there has been no logging to date and no mining since 1974. The park encompasses the headwaters of eight different drainages, seven of which have some form of road or trail access into the park. The ease of public access from many directions almost doubled

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Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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visitor use between 1976 and the present. In 1984, approximately 12,300 people visited the park (British Columbia Parks Division 1984). Valhalla Park was established in 1983. It has a limited, primitive, and unmaintained trail system. Few visitors travel its remote wilderness but significant use occurs at low elevations along the shore line of Slocan Lake. Valhalla is a Class "A" park designated for natural landscape representation and limited recreational development. No resource extraction is allowed.

Both parks are in the Interior Wet Belt Zone of the province, which has diverse biogeoclimatic subzones ranging from moist western redcedar (Thuja plicata)-western hemlock (Tsuga heterophylla) in some of the valley bottoms to alpine tundra in the high country (Utzig and others 1983). The damp interior climate fosters a rich diversity of abundant grizzly bear foods in some of the biogeoclimatic subzones of these parks.

Grizzly bears and black bears (U. americanus) are common in both parks. The most abundant ungulate is the mountain goat (Oreamnos americanus), with some mule deer (Odocoileus hemionus), and white-tailed deer (O. virginianus). Columbian ground squirrels (Spermophilus columbianus) and hoary marmots (Marmota caligata) are two of the common small mammals in the high country. Grizzly bears feed on these species opportunistically. Grizzly bear hunting has been allowed in both park areas and continues under existing park policy. Hunter kills, however, have been negligible.

METHODS

We used the transect method of grizzly bear habitat evaluation as described by Herrero and others (1983). Approximately 20 man-days of transect surveys were done in the summer-fall of 1983 in Valhalla Park and 40 man-days in the summer-fall of 1984 in Kokanee Glacier Park.

Transects were routes walked along trails or pathless areas. These transects were usually laid out to sample the apparent bear habitats in an area. These habitats were first determined by preliminary delineation on 1:15,840 air photos and more finely located by inspection in the field. Where a park development was proposed, transects were also laid out to cover these areas. Each transect was divided into a number of segments based primarily on assumed habitats or topographic units. Each transect segment was assigned a number and the route marked on 1:50,000 topographic maps.

Along each transect segment, we subjectively evaluated potential bear foods and their use as well as other bear sign. The evaluation of the food items for habitat potential (capability) involved rating each species along a segment according to high, medium, low, or trace densities. These ratings were relative to its occurrence in other portions of the study area. In making these ratings, the experience of the field worker in the area was very important.

Ratings of potential food items were based on the known diet of grizzly bears in ecologically similar areas of the Selkirk Mountains (Hamer 1974; Mundy 1968; Simpson and others 1984). As the study progressed, the list of potential foods was modified from results of an ongoing feeding site and scat analysis. We rated 30 potential foods, which included corms and roots, green vegetation, berries, and animal matter (table 1).

Along each segment the areal extent of some foods was noted, for example, the size of a patch of mountain huckleberry or the confinement of cow parsnip or common horsetail to a narrow stream margin. Where possible, the areal distribution of foods was marked on 1:50,000 maps and 1:15,840 air photos. Also taken into account were general vegetative characteristics and the apparent ease of digging of the substrate for grizzlies attempting to unearth underground foods such as corms of glacier lilies. Besides the evaluation of foods, the number of diggings, scats, tracks, beds, rub trees, and other sign was recorded. We attempted to indicate age of all bear sign.

The next step was to assign a rating (high, medium, low, or trace) for overall potential and actual use of each habitat or segment for each season (spring, summer, and fall). It was important to rate both potential and use, since use varies from year to year. The habitat potential was based primarily on the relative abundance of food items and the importance of each food for each season as determined by other studies carried out in ecologically similar areas (Hamer 1974; Mundy 1963; Simpson and other 1984) and an ongoing scat and feeding sign analysis. The use for each season was subjectively rated (when possible) on the basis of the quantity, types, and ages of sign. At the end of the field season, the ratings from different transects in a valley or area were subjectively combined to give an overall rating of seasonal potential and use for the valley or area.

We were careful to differentiate sign left by grizzly bears from sign left by black bears. There is little evidence that black bears dig for corms, roots, or ground squirrels (Herrero 1985); therefore all diggings, except those apparently for ants and wasps, were assumed to have been made by grizzlies. Scats and feeding sign on green vegetation were more difficult to differentiate as to species of bear. There are no published criteria for differentiating black bear and grizzly scats (Hamer and others 1981); therefore we used associated signs such as tracks and hairs. Grizzly bear tracks were differentiated from black bear tracks by the longer front claws, lesser arc of the toes and greater chance of the toe imprints being joined (Lloyd 1979). Hairs of grizzlies could be differentiated when they were silver tipped. The elevation of the sign was sometimes used to differentiate because grizzlies tend to range at higher elevations at certain times of the year than do black bears.

Table 1.--Tentative food items of grizzly bears used in data sheet for evaluating grizzly bear habitats

Habitat Evaluation

Transect number:
Date:

Location:

Roots and Corms:	Transect segment							
Glacier lily (Erythronium grandiflorum)								
Western spring beauty (Claytonia lanceolata)								
Bog orchid (Habernaria spp.)								
Cicely (Osmorhiza spp.)								
Green Vegetation:								
Horsetail spp. (Equisteum arvense)								
Grasses (Gramineae)								
Sedges (Carex and others)								
Mountain sorrel (Oxyria digyna)								
Indian hellebore (Veratrum viride)								
False Solomon's seal (Smilacina racemosa)								
Twisted stalk (Streptopus amplexifolius)								
Meadow rue (Thalictrum occidentale)								
Lady fern (Athyrium felix-femina)								
Stinging nettle (Urtica lyallii)								
Cow parsnip (Heracleum lanatum)								
Queen Anne's lace (Angelica arguta)								
Lovage (Ligusticum canbyi)								
Berries:								
Mountain huckleberry (Vaccinium membranaceum)								
Blue huckleberry (V. ovalifolium)								
Swamp gooseberry (Ribes lacustre)								
Sitka mountain ash (Sorbus sitchensis)								
Black elderberry (Sambucus melanocarpa)								
Red raspberry (Rubus idaeus)								
Devil's club (Oplopanax horridum)								
Bracted honeysuckle (Lonicera involucrata)								
Animal Matter:								
Ants								
Columbian ground squirrel								
Hoary marmot								
Deer								
Mountain goat								

We then related available information on grizzly bear habitats to existing and proposed trails, camping areas and mountain huts by overlaying both on 1:50,000 topographic maps. We subjectively decided the potential for grizzly-people conflicts. Although grizzly habitat information was used to rate hazards, other factors were also considered: cumulative developments, visitor use trends, previous garbage-food problems, timing of people's use of the area versus timing of grizzly's use, previous bear sightings and encounters, possible travel corridors, dens, degree of visibility in the habitat for sighting bears, and associated noise such as nearby mountain creeks.

RESULTS AND DISCUSSION

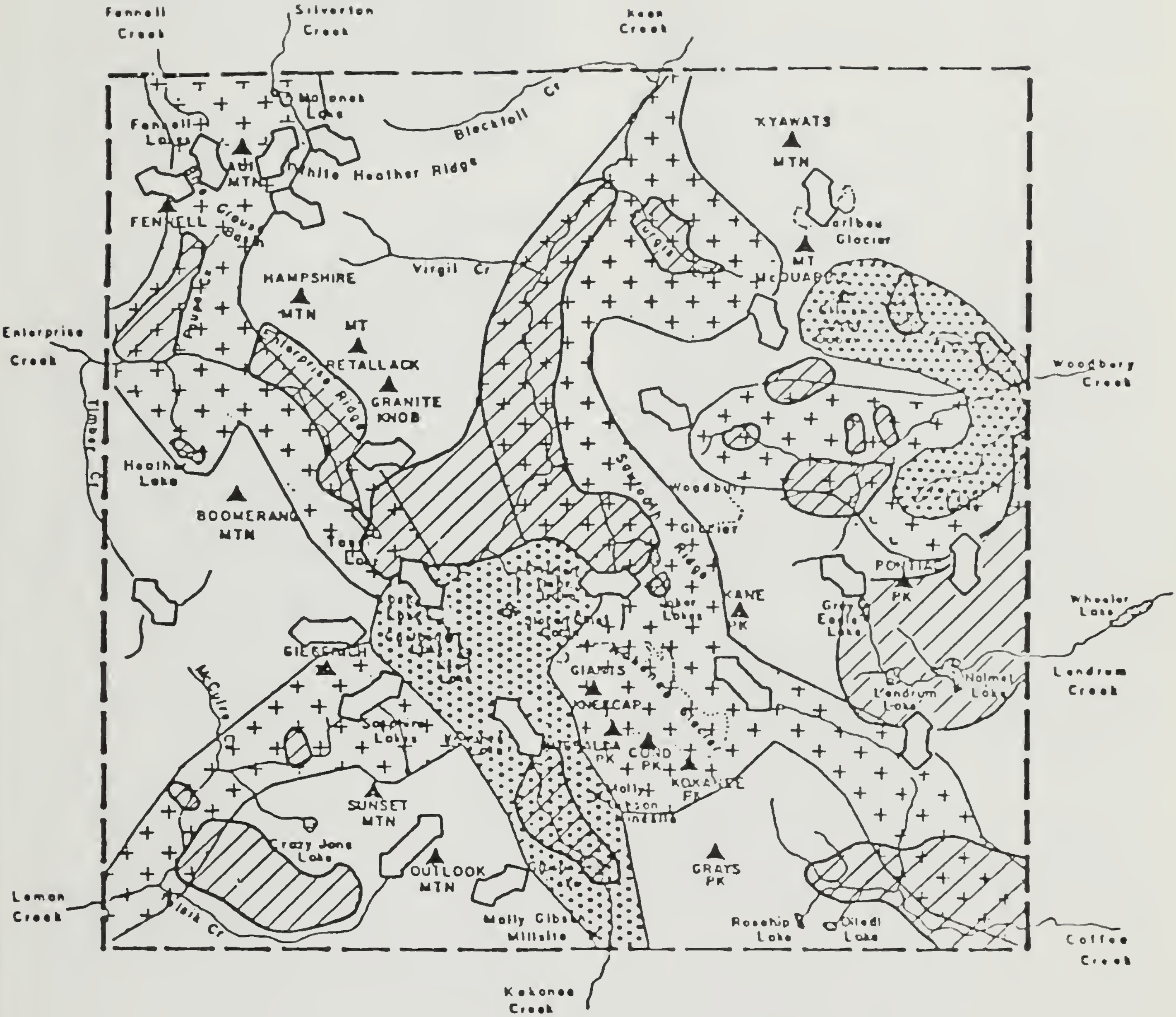
To illustrate our work we present examples of applying the transect method to different areas and situations in Kokanee and Valhalla Parks (McCrory 1984, 1985).

Master Planning

In Kokanee Glacier Park the draft master plan was prepared in 1981 after most park development had taken place but several years before the study of grizzly bear habitats began. As part of the master plan, areas were zoned for intensive, backcountry, and wilderness use.

Information we collected subsequently on grizzly bear habitats showed that some important habitats overlapped with areas zoned for intensive and backcountry visitor use, whereas others did not and fell within the wilderness category (fig. 1).

In one area zoned for backcountry use (Coffee Creek) and proposed enhancement of a historic trail, it was found that the trail corridor passed through a mosaic of habitats of high spring through fall capability for grizzlies. Grizzly use appeared high for summer and fall. It was recommended that the area be rezoned as wilderness and the trail closed.



Intensive use subzone

Back country use subzone

Wilderness subzone

Important grizzly bear habitats

Possible grizzly bear travel corridors, mountain passes

Figure 1.--Important grizzly bear habitats and zoning in 1981 master plan for Kokanee Glacier Provincial Park. Scale: 1 cm = 1 km.

The main area of conflict identified in Kokanee Glacier Park was in the central region, where master plan zoning for intensive use overlapped with major components of grizzly bear habitats. Within this intensive use zone important habitats included a large area of slide paths and wet meadows that were used in summer by as many as four grizzlies and an upland area that appeared to be an important travel corridor and Columbian ground squirrel feeding area for grizzlies. Five mountain passes converge in this upland area. Just to the north of the area zoned for intensive use was a major huckleberry feeding area where there have been sightings of as many as five grizzlies.

Road access to the central region facilitates high visitor use. A network of hiking trails, campsites, and a mountain hut attract increasing back country use that overlaps with important grizzly habitats. Since 1976, back country visitor use has nearly doubled to 3,263 visitors per year and there have been at least 12 non-injurious incidents between park visitors and mother grizzlies. In Glacier Park, MT, Martinka (1982) has documented the increase in human-grizzly confrontations as human visitation increases. There is serious concern that zoning the central region of Kokanee Glacier Park for intensive use and encouraging the introduction of more novices to the wilderness will eventually lead to injurious confrontations between people and grizzly bears.

We recommended that the central region of Kokanee Glacier Park be rezoned when the master plan is revised and that the new zoning recognize the fairly high bear hazard. Other areas of lower bear hazard were identified in Kokanee Glacier and Valhalla Parks. These areas could be zoned for more intensive visitor use.

For the new Valhalla Park, all information on grizzly bear habitat was integrated into an ongoing master plan. Important grizzly habitats were incorporated into a "natural feature subzone" that designated special wildlife habitats. Two major valleys identified as having extensive grizzly habitats in all seasons were designated as natural feature subzones where no development would take place. In other instances, proposed developments were generally planned to avoid important grizzly habitats; some existing developments such as trails were allowed where the hazard could be controlled by methods such as trail rerouting.

Mountain Huts

Mountain huts are a form of public backcountry accommodation in Valhalla and Kokanee Glacier Parks. Although they provide safer overnight facilities in grizzly country, huts tend to become destination points that increase back-country use.

In Valhalla Park, grizzly bear habitats in the area of one proposed and one existing hut were compared to illustrate the usefulness of the transect method of grizzly habitat evaluation. Habitat transects in the area of a proposed hut in the headwaters of Nemo Creek showed the surrounding alpine meadows to have a high habitat capability for all seasons because of high densities of glacier lily, grasses, and sedges. Meadows there were extensively dug by grizzlies feeding on glacier lily corms and, to a lesser degree, on Columbian ground squirrels. We found no suitable alternate hut locations and recommended that the hut not be built. In Mulvey Basin a mountaineering club built a plywood hut in the 1960's. Although the surrounding alpine meadows were shown to have a low habitat capability and use, the hut bordered the main valley, which had a high capability and use. It was recommended that a more suitable location for a replacement hut was higher in the alpine basin and thus farther from the prime habitat.

Camping Areas

In Kokanee Glacier Park, one example shows the usefulness of the transect method in helping to evaluate the potential for grizzly bear-people conflicts at existing camp sites. Kokanee Lake camp site is located in the central region zoned for intensive use. Habitat transects of the surrounding subalpine meadows showed a low summer and fall habitat potential. There was a trace of grizzly use mostly comprised of diggings for glacier lily corms at the camp site; however, the camp site is only 0.25 km from a grizzly summering area with high habitat potential and use. It is also located in a mountain pass that grizzlies apparently use as a travel route. In 1982 a subadult grizzly that had apparently been digging for glacier lily corms and garbage buried at this camp site dragged a pack away from a tent; as a result the camp site was closed permanently in 1984.

In Valhalla Park, two examples demonstrate the usefulness of information on grizzly bear habitats in locating new back country camp sites. A proposed group camp site in alpine meadows at Gwillim Lakes was approved when transects showed the large meadows have only a trace capability to support grizzlies. A proposed camp site at a lake 6 km down the valley, however, was not advised because it was in an area with high summer capability and use. Wet meadows around the lower lake shore produce high densities of horsetail, sedges, and grasses. Beds, scats and tracks showed a high summer use by grizzlies, including a mother with young.

Trails

Grizzly bear habitat information was useful in identifying potentially hazardous areas along proposed or existing trails. Although encounters can occur along any point of a trail, we believe that they are most likely to occur near grizzly feeding areas that are crossed by the trail. Obviously, the larger the feeding areas crossed and the higher the grizzly use at different seasons, the higher the hazard. Following are three examples of trail situations.

In Kokanee Glacier Park, the trail to Silver Spray Hut passes through large areas of mature forest with an overall trace-low habitat potential and grizzly utilization; however, the trail passes for 100 m through a slide path that has a moderate grizzly potential for all seasons. Grizzly use of the 100 m segment appeared moderate in late summer and fall. Since this slide path concentrated feeding activities of grizzly bears more than other habitats crossed by the trail corridor, encounters between people and grizzly bears are most likely to occur at this site. Recommendations made to reduce the bear hazard included clearing overgrown areas of the trail through the slide to 3 to 4 m wide and straightening the trail to eliminate blind corners. Small warning signs posted at either side of the slide path and at the trail register were also advised.

A different problem exists on the Joker Millsite-Slocan Chief Cabin Trail in Kokanee Glacier Park. This well-used trail passes for 3 km through a major huckleberry feeding area for grizzlies. Since 1976, there have been at least four noninjurious incidents between hikers and grizzlies on this trail. In 1984, a seasonal trail closure was instituted throughout the huckleberry season. Other trails provide alternative access and present a lower risk of encounters.

In Valhalla Park, habitat transects along the access trail to Mulvey Hut showed that the trail passes for 3 to 4 km through a mosaic of habitats that have a high capability. These habitats include wet meadows interspaced in forest, slide paths and an old burn. Together these areas produce abundant and varied grizzly foods. Scats and signs of feeding on green vegetation, glacier lily corms, and huckleberries indicated high grizzly use for all seasons. Because the trail could not practically be rerouted to avoid this large hazardous area, it was abandoned in favor of alternative access routes through other valleys.

CONCLUSIONS

This study shows the usefulness of the transect method of habitat evaluation when time and budget constraints preclude the use of important but expensive long-term methods of determining grizzly bear habitat availability and use. We believe that the transect method should only be used, however, by experienced researchers and only where reliable information on grizzly bear food habits is available from an ecologically similar area. An ongoing analysis of bear scats and feeding signs in the study area is also useful in refining food habit information as the study progresses.

The information on grizzly bear habitats provided by the transect method can be integrated into park master plans. Zoning areas for different levels of visitor use can help reduce chances of conflicts with grizzlies. When grizzly bear habitat information is not used in master planning, visitor use may increase in important grizzly habitats, increasing the chances of incidents between humans and bears.

The transect method is also a quick, cost-efficient, and reliable means to incorporate information on grizzly bear habitats into the planning and safer location of trails, camping areas, and mountain huts before they are built. Where such developments already exist, the transect method is useful in evaluating the degree and location of hazards and making management recommendations that endeavor to reduce people-grizzly conflicts.

The transect method is useful in covering large areas and in locating important feeding areas in microhabitats that are too small to be detected from air photos. As well, the transect method relates the importance of habitats to the seasonal diet of grizzlies, streamlining the use of such information for park planning and management.

One serious deficiency of the transect method is that it uses information on existing vegetation to evaluate grizzly habitats in relationship to permanent park facilities. This does not allow for long-term changes in habitats and bear foods, for example, those resulting from wildfires that could substantially affect grizzly bear use of the area of a park development. Other limitations of the transect method of habitat evaluation are considerable. Important habitats can be missed. The subjective methods employed can also lead to errors in judgment. As well, interpretation of grizzly bear habitat use and people-bear hazards is limited by lack of baseline information on the bears' use of different habitats, movement patterns, sex and age differentiation of habitat use, changes in habitat use because of population fluctuations, and other factors. However, the results of this study at least crudely evaluate grizzly bear habitat use at a level that is useful in making timely planning and management decisions to attempt to reduce human-grizzly conflicts. Longer term studies involving radio-telemetry and more in-depth habitat delineation were recommended in both parks to expand the data base and refine strategies to manage human-grizzly conflicts.

REFERENCES

British Columbia Parks Division. Data handbook. 1984. Unpublished paper on file at: Ministry of Lands, Parks and Housing, Kamloops, BC.

Gebhard, J. Annual activities and behaviour of a grizzly bear family. Paper delivered to: 6th International Conference on Bear Research and Management, Grand Canyon, AZ; 1983 February 18-22.

Hamer, David. Distribution abundance and management implications of the grizzly bear and mountain caribou in the Mountain Creek watershed of Glacier National Park, British Columbia. Calgary, AB: The University of Calgary; 1974. 164 p. M.S. thesis.

Hamer, David; Herrero, S.; Rogers, L. Differentiating black and grizzly bear faeces. Wildlife Society Bulletin. 9(3):210-212; 1981.

Herrero, Stephen. Bear Attacks: their causes and avoidance. Piscataway, NJ: Nick Lyons Books, Winchester Press; 1985. 287 p.

Herrero, Stephen; McCrory, W.; Pelchat, B. The application of grizzly bear habitat evaluation to trail and campsite locations in Kananaskis Provincial Park, Alberta. Paper delivered to: 6th International Conference on Bear Research and Management. Grand Canyon, AZ: 1983 February 18-22. 30 p.

Lloyd, Kevin. Aspects of the ecology of black and grizzly bears in coastal British Columbia. Vancouver, BC: The University of British Columbia; 1979. 125 p. M.S. thesis.

Martinka, C. J. Rationale and options for management in grizzly bear sanctuaries. Paper presented to the 47th North American Wildlife and Natural Resources Conference. Portland, OR; 1982. 15 p.

McCrory, Wayne P. Grizzly bear habitat capability and use in relation to recreational facilities in Valhalla Provincial Park. 1984. Unpublished report on file at: British Columbia Parks Division: Kamloops, BC: 153 p.

McCrory, Wayne P. Grizzly bear habitat and outdoor recreation in Kokanee Glacier Provincial Park, conflicts and recommendations. Volume I: summaries and recommendations. 1985. Unpublished report on file at: British Columbia Parks Division, Kamloops, BC: 118 p.

Mundy, Keith. Ecology of the grizzly bear (Ursus arctos L.) in Glacier National Park, British Columbia. Edmonton, AB: The University of Alberta; 1963. 103 p. M.S. thesis.

Pearson, Arthur M. Habitat, management and the future of Canada's grizzly bears. In: Mosquin, T.; Suchal, C., eds. Canada's threatened species and habitats. Canadian Nature Federation, Toronto, Special Publ. 6; 1977: 33-40.

Simpson, K.; Hebert, K. B.; Woods, G. P. Habitats and management of the grizzly bear (Ursus arctos L.) in the Columbia Mountains of British Columbia. 1984. Unpublished report on file at: Fish and Wildlife Branch, Nelson, BC: 42 p.

Stelmock, Jim S. Seasonal activities and habitat use patterns of brown bears in Denali National Park - 1980. Fairbanks, AK: The University of Alaska; 1981. 110 p. M.S. thesis.

Utzig, Greg F.; Comeau, P. G.; Macdonald, D. L. (and others). A field guide for identification and interpretation of ecosystems in the Nelson Forest Region. 1983. Authors' draft on file at: British Columbia Ministry of Forests, Nelson, BC: 77 p.

Session II—Habitat Mapping and Evaluation

Chaired by:

Glenn Erickson, Chief, Statewide and Special Projects, Montana Department of Fish, Wildlife, and Parks, Helena, MT

Don Despain, Research Biologist, National Park Service, Yellowstone National Park, WY

GRIZZLY BEAR HABITAT COMPONENT MAPPING IN THE NORTHERN REGION

Rose Leach

ABSTRACT: The U.S. Department of Agriculture, Forest Service, Northern Region's grizzly bear habitat component mapping project comprises three northern ecosystems: Northern Continental Divide, Cabinet-Yaak, and Selkirk Mountains. Mapping objectives are to (1) better describe National Forest occupied grizzly bear habitat and management situations 1, 2, and 3 areas within occupied habitat, (2) coordinate with other resource management activities, (3) develop habitat improvement projects, (4) analyze relative habitat capabilities, and (5) provide data for cumulative effects analysis projects. Maps show best estimates of areas important to the bear but not the entire picture of grizzly bear habitat. Advantages are map accuracy, visual presentation, and adaptability to future research innovations.

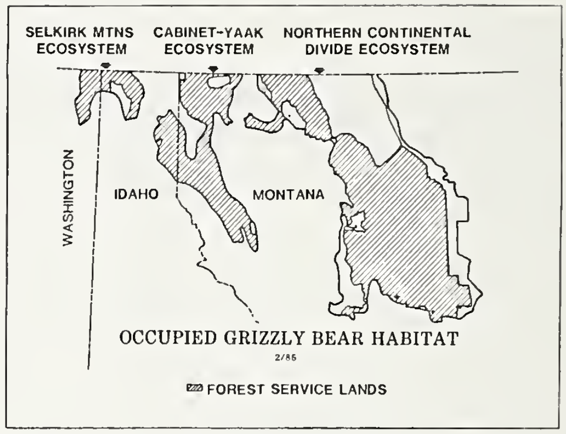


Figure 1.--National Forest lands in grizzly bear-occupied habitat.

PRESENT PROGRAM

Goals and Objectives

Grizzly bear habitat component mapping is one of the U.S. Department of Agriculture, Forest Service, Northern Region's contributions toward grizzly bear recovery. The objectives of component mapping are to (1) better describe National Forest occupied grizzly bear habitat (U.S. Department of the Interior, Fish and Wildlife Service 1982) and management situation 1, 2, and 3 areas (USDA Forest Service and USDI National Park Service 1979) within occupied habitat; (2) coordinate with other resource management activities; (3) develop habitat improvement projects; (4) analyze relative habitat capabilities; and (5) provide data for cumulative effects analysis programs.

Methods

The Region's project area includes three northern ecosystems: Northern Continental Divide (NCD), Cabinet-Yaak (C-Y), and Selkirk Mountains (SM) (fig. 1). Our program there involves mapping of seven National Forests (including one in the Pacific Northwest Region), located in Washington, northern Idaho, and western Montana. Portions of the Northern Region in the Yellowstone ecosystem are included in another paper.

Because bears have only 6 to 9 months to eat enough to sustain themselves for an entire year, one approach to managing for bears is to manage for productive feeding sites. Servheen (1981) indicates that bear movements within home ranges are dictated by seasonal availability of foods and denning sites. Thus, researchers have developed grizzly bear habitat component concepts based on key bear foods and denning requirements (Madel 1982; Servheen and Lee 1979; Servheen 1981).

In the Northern Region mapping program, grizzly bear habitat components are consistently recognizable sites with a structural or vegetative identity of value to grizzly bears (USDA Forest Service 1983). Many components apply to all three northern ecosystems; some are unique to certain areas. Components are based on vegetation plots (Pfister and others 1977) and are described in detail in map project writeups, including Madel (1982) for the Cabinet Mountains, MT; Houghton and others (1983) for the Purcell and Cabinet Mountains, ID; Leach and Tirmenstein (1983) for Lolo National Forest, MT; Berner and others (1984) for Helena National Forest, MT; Tirmenstein and Cline (1984) for Swan-Scapegoat, MT; and Ash (1985) for the Whitefish Range, MT. Concurrent bear telemetry studies (conducted by other groups) and bear sighting and sign information from mapping crews further validate habitat components.

Each component is assigned a season or seasons of use, based upon the bear food plants present. Forest Service biologists and other users of component maps are primarily interested in four classes of bear foods: (1)

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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grasses and sedges used in early spring and at high elevations in summer (for example, Grammineae and *Carex* spp.); (2) wet site forbs used in spring (for example, umbels such as *Angelica* spp., *Ligusticum* spp., and *Heracleum lanatum*); (3) roots and corms used in spring and summer (for example, *Claytonia lanceolata* and *Erythronium grandiflorum* after it goes to seed); (4) fruits used in fall (for, example, *Vaccinium* spp., *Sorbus scopulina*, *Shepherdia canadensis*, and *Amelanchier alnifolia*). The project writeups previously listed include area-specific key bear foods.

Most components are located in forest openings, although timbered areas are also important to bears. To date, mappers have no simple and accurate method to stratify timbered areas because most components under timber canopies are not easily recognized by aerial photo interpretation. Currently, crews are able to map only those timbered components that they happen to encounter in the field. The Northern Region is investigating other mapping techniques (LANDSAT, high-elevation infrared photography, or other remote sensing techniques) to facilitate mapping forested areas. If promising, these methods could facilitate mapping in wilderness, timbered areas, management situation 2 and 3 areas, and previously unmapped areas including other ownerships.

Components are usually named after the hierarchy of dominant vegetation within them, followed by a site description. Examples are mixed shrubfield/snow chute and mixed shrubfield/cutting unit.

Maps are digitized and stored on a computer coordinate system, so that all maps are oriented to each other. A user can retrieve the information by land section, by bear unit, or by ecosystem, for example. The Region will use some type of Geographic Information System (GIS) to organize the digitized information. The Washington Office is evaluating which GIS the Forest Service will use.

Results

The Northern Region contains about 43 percent of all occupied grizzly bear habitat in the lower 48 States (fig. 2; USDI Fish and Wildlife Service 1982), most of which occurs in the three northern ecosystems: NCD, C-Y, and SM.

In summer 1984, the Region employed 23 seasonal field technicians to map components, and I expect a similar number for 1985. Qualifications for mappers include plant identification skills and ability to use aerial photographs and topographic maps.

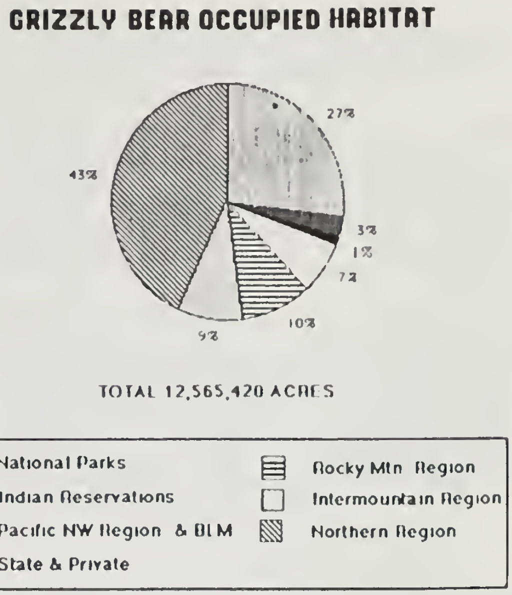

Figure 2.--Ownership or management agency of grizzly bear-occupied habitat. "Regions" refer to National Forest System regions.

After summer 1985, the Region expects to have completed all mapping in the C-Y and SM ecosystems and about 30 percent of the NCD ecosystem (fig. 3). Most of the remaining 70 percent of the NCD ecosystem to be mapped is in wilderness (fig. 4). The Region plans to complete the nonwilderness portion of the NCD ecosystem in summer 1987 and the wilderness portion in 1991. If workers can use more sophisticated mapping methods, the wilderness portion will be finished much sooner.

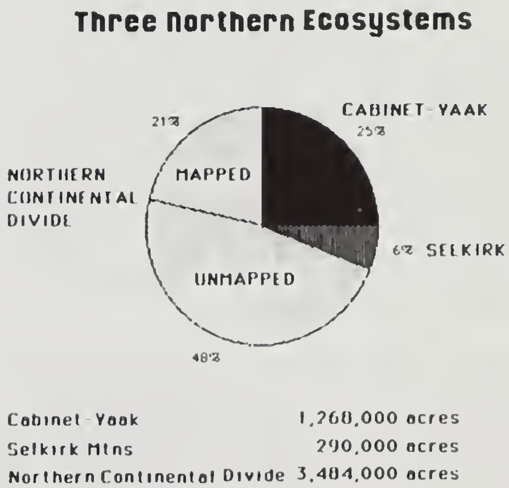

Figure 3.--Grizzly bear habitat component mapping accomplishments through 1985.

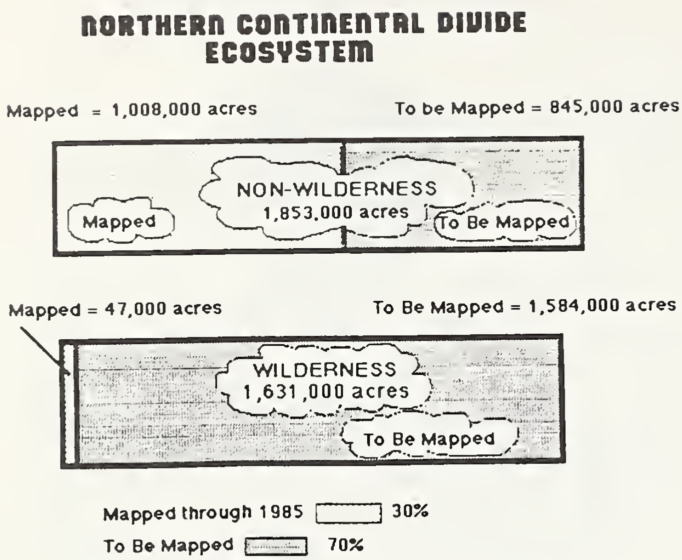

Figure 4.--Grizzly bear habitat component mapping accomplishments in the Northern Continental Divide Ecosystem.

FUTURE DIRECTION

Component maps are evolving into more complete vegetation maps which display all openings, rather than displaying only the most productive sites as originally described by Madel (1982). Mappers will differentiate openings by labeling them according to the number and percent coverage of key bear foods present. Each ecosystem will use its own list of key bear foods, based on data from the nearest research project. In areas with few local bear-food studies, mappers will record the percent coverage of the predominant plant species in the opening. Thus, component values may be assigned once biologists agree on which plants are key bear foods in the area. Because vegetative data are recorded on permanent field plot sheets, the relative value of each area can be reassessed as new bear-use data become available from research projects. Mapping all openings has several advantages: (1) mapping is repeatable; (2) openings are distinguishable; (3) maps are more complete.

As mappers encounter areas that do not seem to fit descriptions of previously described components, they will take vegetation plots (Pfister and others 1977) to describe the area and tentatively call it a new component. The Region is now analyzing all the plot forms, by ecosystem, to determine if mappers have taken adequate data to describe both old and new components. Decisions on component definitions are made at the Regional office, based on this analysis of vegetative plot forms.

Grizzly bear component mapping is not a one-time, static effort. As in other forms of Forest Service vegetative mapping (for example, timber and range), the maps will be periodically updated. The National Forests involved expect to do this every 5 to 10 years.

Biologists and others concerned with component maps welcome further refinement of the mapping system. For example, Jon Almack's current study in the Idaho Panhandle National Forests has prompted the Forest to include an additional area into the SM mapping project. The reason: a telemetered bear from the study extensively used an area not previously designated for component mapping.

Shortcomings and Advantages

To properly interpret maps, users must keep in mind the limitations of the mapping system. In general, maps show our best estimate of "red flag" areas that are important to the bear but not the entire picture of grizzly bear habitat. For example, maps do not display "space" as an essential part of grizzly bear habitat. In addition, the concept of cover is not addressed. As mentioned previously, components under tree canopies are underestimated. When mapping shrubfields, mappers unfortunately have no indication of how good or poor berry production may be. Also, component mapping is a very time-intensive process and is especially slow where access is poor, as in wilderness. Therefore, to better understand the mapping process, we encourage biologists and other District personnel to talk with and occasionally accompany crews in the field.

Initially, habitat component maps are intended to illustrate general information on the potential value of a given area to provide forage or denning habitat. When a specific project is proposed, District biologists must visit the site to determine the actual values of the area and develop any necessary constraints or coordination measures to protect those values. Eventually, when biologists from each ecosystem develop appropriate models, component maps will provide the vegetative base to run the cumulative effects analysis, as discussed in another symposium paper.

One advantage to intensive ground mapping for components is that maps are presumably very accurate. In addition, component maps are a good tool for visually displaying grizzly bear habitat and are necessary for cumulative effects analyses. Finally, the component mapping system is robust enough to permit incorporation of future research findings and more sophisticated mapping techniques.

REFERENCES

Ash, M. Grizzly bear habitat component descriptions, Whitefish Range, Flathead and Kootenai National Forests, Glacier View Ranger District. Kalispell, MT: Flathead National Forest; 1985. 32 p.

Berner, K.; Broschart, M.; Fralick, G.; Pyle, C. Grizzly bear habitat component mapping, Lincoln District, Helena National Forest. Helena, MT: Helena National Forest; 1984. 8 p.

Houghton, P.; Hompesch, R.; Scott, D.; Mack, S. Grizzly bear habitat component mapping, Cabinet-Yaak Ecosystem, Idaho Panhandle National Forests. Coeur D'Alene, ID: Idaho Panhandle National Forests; 1983. 11 p.

Leach, R.; Tirmenstein, D. Grizzly bear habitat component mapping, Seeley Lake and Thompson Falls Ranger Districts. Missoula, MT: Lolo National Forest; 1983. 8 p.

Madel, M. Grizzly bear habitat delineation and reconnaissance in the Cabinet Mountains: a procedural description. Libby, MT: Kootenai National Forest; 1982. 37 p.

Pfister, R; Kovalchik, B.; Arno, S.; Presby, R. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Servheen, C. Grizzly bear ecology and management in the Mission Mountains, MT. Missoula, MT: University of Montana; 1981. 139 p. Ph.D. dissertation.

Servheen, C.; Lee, L. Mission Mountains grizzly bear studies, an interim report. Missoula, MT: University of Montana Forest and Conservation Experiment Station; 1979. 299 p.

Tirmenstein, D.; Cline, M. Grizzly bear habitat component mapping--1984, Swan-Scapegoat Northern Continental Divide Ecosystem. Missoula, MT: Lolo National Forest; 1984. 24 p.

U.S. Department of Agriculture, Forest Service. Criteria for mapping grizzly bear habitat constituent elements. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region; 1983. 31 p.

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, National Park Service. Guidelines for management involving grizzly bears in the Greater Yellowstone area. Washington, DC; 1979. 136 p.

U.S. Department of the Interior, Fish and Wildlife Service. Grizzly bear recovery plan. Washington, DC; 1982. 195 p.

GRIZZLY BEAR HABITAT IN THE KIMSQUIT RIVER VALLEY, COASTAL BRITISH COLUMBIA: CLASSIFICATION, DESCRIPTION, AND MAPPING

Allen Banner, Jim Pojar, Rick Trowbridge, and Anthony Hamilton

ABSTRACT: The Kimsquit River valley, a ruggedly mountainous watershed on the central mainland coast of British Columbia, is the location of an interagency grizzly bear research project initiated in 1982. The project has as one objective the identification of seasonal habitat requirements of coastal grizzlies. This requires habitat classification, description, and mapping. The intensively studied portion of the valley occurs along the lower river and includes about 70 percent of the relocations of two intensively monitored, adult female grizzlies equipped with radio transmitters. Habitat classification for the study area (excluding the estuary) was linked to an existing, climax-based ecological classification, modified to accommodate the extensive seral vegetation that has developed after geomorphic and logging disturbances. Ecosystem description and mapping were based on interpretation of pretyped, 1:20,000 color aerial photography and on ground sampling involving transects and detailed and reconnaissance-level plots. The map area was approximately 5 000 ha and included seven climax forest ecosystem units and two nonforested units--wetlands and avalanche tracks. The forested units were designated according to eight successional stages based on vegetation physiognomy and were also subdivided into 19 variations based on species composition. Although vegetation was primarily used to delineate polygons, a landform/soil component was also included in the map units. A total of 419 polygons were mapped as pure or complex units. The maps were digitized and entered on a computer-assisted mapping system, so that derivative maps for wildlife interpretations could be produced. Our work provides a framework for further analysis and evaluation of grizzly habitat by the wildlife biologists in the research team.

INTRODUCTION

One of the major wildlife management problems in British Columbia centers on coastal grizzly bears (Ursus arctos) and their habitat. In 1982, the British Columbia Ministries of Environment and Forests started a research project in the Kimsquit River valley to address this problem (Archibald and Hamilton 1982). One project objective has been to identify seasonal habitat requirements of coastal grizzlies. This requires habitat classification, description, and mapping. When British Columbia Forest Service research staff were asked to do the work, we decided to use an existing ecosystem classification of the region (Yole and others 1982) as a framework for the study.

Recent studies describing techniques for mapping grizzly bear habitat in the Rocky Mountains have dealt with interior mountain systems where large areas of grizzly habitat occur in alpine and subalpine zones (Craighead and others 1982; Hamer and Herrero 1983). These studies have only limited application to coastal mountain valleys such as the Kimsquit, where grizzly habitat occurs predominantly below treeline and is largely concentrated in valley-bottom ecosystems associated with important salmon rivers.

We initially stratified the Kimsquit watershed into three study areas--the estuary, the lower valley, and the upper valley--based on biogeoclimatic considerations, workload, and concentration of effort by the bear biologists. A private consultant classified and mapped the estuary (Clement 1984b) and the upper valley (Clement 1984a) separately. We studied the lower valley below 500 m, which includes about 70 percent of the relocations of two intensively monitored, adult female grizzlies equipped with radio transmitters.

We needed to modify and expand the existing, climax-based ecosystem classification for the lower valley to accommodate the extensive seral vegetation resulting from past geomorphic and logging disturbances and also because we considered description and mapping of seral ecosystems essential for wildlife interpretations. Most forest ecosystem research in British Columbia has been done in mature or climax stands. A few coastal studies have dealt primarily (Mueller-Dombois 1959; Houseknecht 1976; Klinka and others 1985) or secondarily (Inselberg and others 1982) with seral forest vegetation. Most forest ecologists in northwestern North America have used stand age, composition, structure, and cover to stratify structural or developmental stages in both seral

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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and mature forests (for example, Thomas 1979; Arno 1982; Henderson 1982; Alaback 1984), and we followed their lead.

The major objective of this paper is to present an approach to ecosystem classification and mapping that provides a framework for evaluating coastal grizzly bear habitat. A detailed description of the classification and mapping project can be found in Banner (1985).

TAXONOMIC CONSIDERATIONS

Nomenclature follows Taylor and MacBryde (1977) for vascular plants (both scientific and common names); Crum and others (1973) for mosses; Stotler and Crandall-Stotler (1977) for liverworts; and Hale and Culberson (1970) for lichens. Soil taxonomy follows Canada Soil Survey Committee (1978). Humus form terminology is after Klinka and others (1981).

STUDY AREA

The Kimsquit River valley is a ruggedly mountainous, 104 000 ha watershed on the central mainland coast of British Columbia (fig. 1). The mouth of the river, at the head of Dean Channel (a huge fiord; fig. 2a), lies 60 km north - northwest of Bella Coola and 120 km inland from the open Pacific Ocean. The watershed is bounded to the east by Tweedsmuir Provincial Park.

Three biogeoclimatic zones (Krajina 1965; Pojar 1983) occur within the valley: the coastal western hemlock zone (CWH) at lower and montane elevations, the subalpine mountain hemlock zone (MH), and the alpine tundra zone (AT). The CWH in the Kimsquit is represented by two subzones: the midcoast drier transitional (CWHh) and the wetter maritime (CWHi). This paper deals only with the CWHh, which occupies the lower 20 km of the valley (Yole and others 1982), extends from sea level to 400 to 500 m elevation, and defines the 5 000 ha study area (fig. 1).

The lower Kimsquit valley has a humid suboceanic climate. Moist Pacific air masses lose much of their precipitation by the time they reach the innermost ranges of the Coast Mountains, yet the moderating coastal influence prevails even this far inland. The closest suitable long-term climate station is at Kemano, 90 km to the northwest. Based on 30-year normals (Environment Canada 1980), Kemano has a mean annual temperature of 6.5 °C. Total annual precipitation averages 1 867 mm with 11 percent falling as snow. June is the driest month, October the wettest. Strong winds, especially during the fall and winter, are a significant climatic feature.

The Kimsquit watershed is part of the Kitimat Ranges of the Coast Mountains (Holland 1976). Topography is very rugged, with mountains rising steeply from the valley floor near sea level to over 2 000 m. Plutonic rocks, mainly quartz

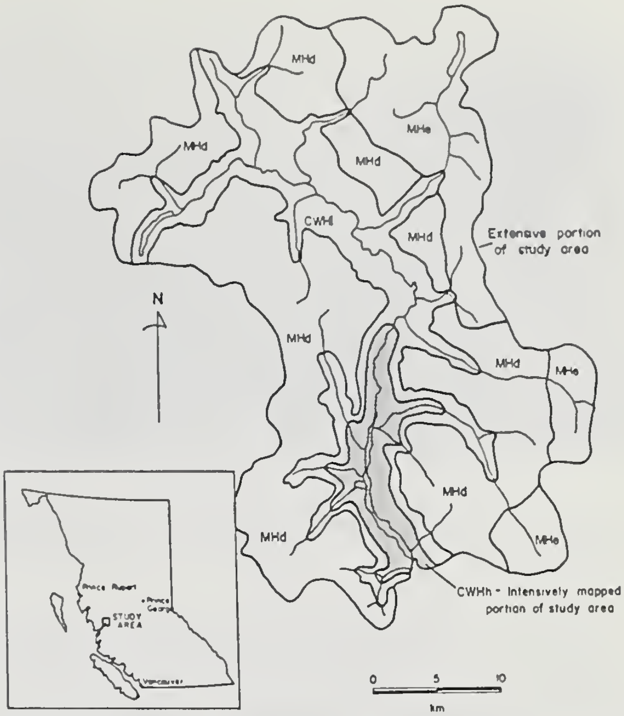

Figure 1.--Map of forested biogeoclimatic zones of the Kimsquit River Valley showing location of the study area. Abbreviations: CWH, coastal western hemlock zone; CWHh, mid-coast drier transitional subzone; CWHi, wetter maritime subzone; MH, mountain hemlock zone; MHd, coastal subzone; MHe, transitional subzone.

diorites and diorites, dominate the bedrock geology of the study area, although metavolcanic greenstone is common on the west side of the valley (Baer 1973).

Landforms and soils are generally typical for the Coast Mountains (Jungen and Lewis 1978). Glacial landforms (including morainal, glaciofluvial, and glaciolacustrine deposits) occur, but the majority of the terrain has been more recently modified by fluvial and colluvial processes and by accumulation of surface organic matter. Fluvial soils are mainly Regosols and Brunisols; colluvial soils are mainly Podzols and Brunisols with some Folisols; soils developed in glacial till typically are Podzols. Soil textures are relatively coarse, generally sandy to loamy; skeletal soils are common. Mor humus forms dominate the forested slopes, whereas fluvial ecosystems typically have Moders and Mulls.

Coniferous forests dominate the vegetation (fig. 2). Climatic climax or zonal forests consist chiefly of western hemlock (Tsuga heterophylla) but contain variable amounts of western redcedar (Thuja plicata) and Douglas-fir (Pseudotsuga menziesii). Dry forests are usually mixtures of western hemlock and Douglas-fir, sometimes with shore pine (Pinus contorta var. contorta). Amabilis fir (Abies amabilis) and Sitka spruce (Picea sitchensis) join western hemlock, redcedar, and sometimes Douglas-fir on

Figure 2.--Photos of the Kimsquit Valley study area. (A) View looking southeast over river mouth and the head of Dean Channel. (B) Black cottonwood-Sitka spruce-devil's club forest community common on the Kimsquit flood plain.

moisture-receiving sites of lower slopes. The most productive forests are the alluvial spruce types on the flood plain. These stands were mostly logged about 1918 (Hamilton 1983); consequently, the lower flood plain presently is dominated by deciduous forests of red alder (Alnus rubra) and black cottonwood (Populus balsamifera ssp. trichocarpa), as well as mixed deciduous/coniferous stands (fig. 2b). Shrub- and herb-dominated communities occur mostly on avalanche tracks, river bars, and recent clearcuts. These clearcuts are the result of logging operations that commenced in 1980 and have continued intermittently to the present, on the west side of the valley.

METHODS

Classification Methods

Refining of the existing climax-based biogeoclimatic classification for the CWHh (Yole and others 1982) and characterizing of ecosystem units involved sampling the range of climax and seral ecosystems in the lower Kimsquit Valley.

Overstory and understory species composition, percentage cover, and vigor, soil profile and site descriptions; and tree mensuration data were collected from a total of 89 plots ranging in size from 300 to 500 m^2. Sampling methods mainly followed those outlined in Walmsley and others (1980). In addition, detailed observations of phenology and berry abundance were made for taxa identified as grizzly bear food plants by the wildlife biologists.

Ecosystem data from the sample plots were summarized on computer-generated tables (Klinka and Phelps 1979; Meidinger and others 1983). With the aid of these computer programs, we used the subjective Braun-Blanquet tabular comparison method (Westoff and van der Maarel 1978) to compare and rearrange plots and ultimately group them into ecosystem units (Pojar 1983).

Mathematical ordination of the vegetation data using the computer program DECORANA (Hill 1979) was also applied to clarify relationships among the sample plots.

A table of prominence values was produced to summarize species cover and constancy for each of the ecosystem units. Prominence values (pv's) were calculated by multiplying each species' mean cover by the square root of its percent frequency among the plots of an ecosystem unit (pv = mean cover x $\sqrt{\text{frequency}}$).

Three categories were used to classify and map climax and seral vegetation: the ecosystem association, successional stage, and variation.

We used the ecosystem association as defined by Pojar (1983): "All ecosystems capable of producing vegetation belonging to the same plant association at climax." The ecosystem association therefore describes the climax potential of an ecosystem regardless of the existing seral plant community.

The category of successional stage describes the present physiognomic or structural development stage of the ecosystem association without reference to species composition. The eight recognized successional stages are summarized in table 1.

We used the variation to further subdivide ecosystem associations into community types based on their present species composition. Some variations may represent minor deviations from the central concept of a climax association, whereas others describe distinct plant communities representing seral stages of associations. This is a broader definition of the variation than that of Pojar (1983) and is conceptually similar to the seral association of Klinka and others (1985).

Closely related successional pathways may be associated with two or more ecosystem associations having similar moisture and

Table 1.--Successional stage categories used to classify and map ecosystems in the lower Kimsquit valley

Category		Description
A.	Nonvegetated or bryoid	Initial stage in primary or secondary succession; little or no residual vegetation except bryophytes and lichens.
B.	Herb pioneer seral	Early successional stage dominated by herbaceous vegetation; some invading or residual shrubs and trees may occur (less than 10 percent cover).
C.	Shrub-seedling pioneer seral	Early successional stage dominated by shrubby vegetation; tree cover less than 10 percent but seedlings and advanced regeneration may be abundant.
D.	Pole-sapling	Midsuccessional stage beginning when young trees (saplings) extend into tall shrub layer (greater than 2 m tall) and crown cover exceeds 10 percent; late in this stage vertical crown differentiation begins, as does self-thinning and pruning; a second shade-tolerant tree species may have begun establishment; understories become poorly developed as stand densities increase.
E.	Mature seral	Late successional stage beginning when initial shade-intolerant trees reach maturity; a second cycle of more shade-tolerant trees has usually become established in understory; openings in the canopy result from death of mature individuals; understories usually well developed.
F.	Young climax	Young stands (40 to 80 years old) dominated by climax (shade-tolerant) species in both the overstory and understory; even- or uneven-aged stands, depending on site history; understories poorly to moderately well developed.
G.	Mature climax	Mature stands (80 to 150 years old) comprised of climax tree species in all tree and regeneration layers; these stands are usually uneven aged and structurally heterogenous; understories usually patchy.
H.	Old growth	Very old (150 to 250+ years old), all-aged, structurally complex stands comprised mainly of climax tree species, although old seral remnants may still be present in upper canopy; standing snags and rotting logs on the ground are typical; understories patchy.

nutrient regimes. Thus, seral variations may not be unique to just one climax association (cf. Huschle and Hironaka 1980). For example, the flood plain spruce-devil's club (Oplopanax horridus) association and the devil's club-fern association share many seral variations.

The ecosystem classification outlined above relies mainly on vegetation to characterize units. Although some ecosystem associations, especially those of the driest and wettest habitats, encompass a narrow range of edaphic characteristics, the more widespread associations occur on a variety of landform and soil types, all sharing similar moisture and nutrient regimes. We considered it important to recognize and map contrasting edaphic characteristics because of their potential effect on successional development and on the response of the ecosystem to external disturbances. We used landform/soil types to denote this component of the mapping units.

Mapping Methods

We mapped the area using 1:20,000 color aerial photography (1982 flight line BCC312). Photo interpretation was based on vegetation and physiographic features, however, polygon boundaries were drawn primarily to represent changes in vegetation. Although landform/soil boundaries often coincided with vegetation boundaries, it was common for two adjacent polygons to have the same landform/soil component.

Minimum polygon size was 0.25 cm^2, which at 1:20,000 represents 1 ha on the ground.

We did "ground-truthing" of pretyped aerial photographs along transects that crossed a maximum number of polygon boundaries. Access was by truck and logging road on the west side of the valley, by boat along the lower portion of the river, by helicopter, and on foot. Polygon boundaries and designations were verified by detailed plot sampling, less detailed polygon inspections, rapid observations along the transects, and, in parts of the lower flood plain, by hovering in a helicopter approximately 30 m above the trees. Field sampling was carried out over the summer of 1983 and required 97 person-days of labor.

After completing the field work, we fixed polygon boundaries and map labels on the aerial

photographs and then transferred them using an epidiascope to a 1:20,000 planimetric base map. British Columbia Ministry of Environment personnel digitized the two map sheets that include the majority of the intensively mapped study area (approximately 4 500 ha) and entered them on the Computer Aided Planning Assessment and Map Production System (CAPAMP). Derivative and interpretive maps for wildlife habitat and other resource applications, as well as summaries by area and frequency of occurrence for each ecosystem unit and landform/soil type, can be produced by this computerized mapping facility.

Map Unit Symbols

We constructed map unit labels using the ecosystem unit and landform/soil type components seen in figure 3. A maximum of three ecosystem units and landform/soil types may be included in a polygon label. An ecosystem unit must occupy at least 5 percent, and a landform/soil type 10 percent, of the polygon to be included in the map symbol. At 1:20,000 and at the sampling intensity achieved in this study, however, polygons may contain up to 15 percent inclusions not denoted in the map symbol. We tried to recognize small inclusions, such as skunk cabbage (Lysichiton americanum) swamps, known to be utilized by the grizzlies.

RESULTS AND DISCUSSION

Ecosystem Classification

Seven forested ecosystem associations and 19 distinct variations were described within the study area (table 2). Two additional ecosystem units important as wildlife habitat were also recognized: nonforested wetlands and avalanche tracks. These units are not, however, classified as ecosystem associations. Both include several distinct plant associations; these represent climax ecosystems in the case of the wetlands, but the avalanche tracks comprise disclimax communities maintained by repeated snow avalanche disturbances.

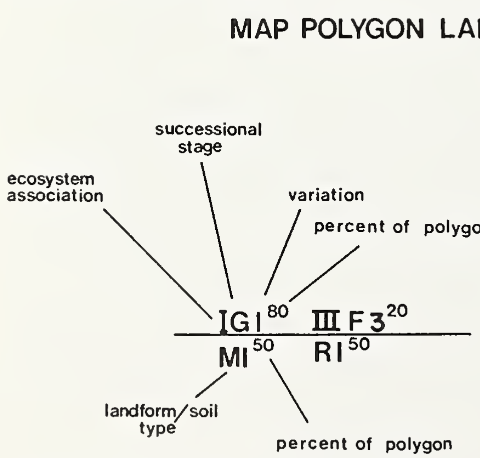

Figure 3.--Format of polygon labels for the ecosystem map.

Table 2.--Ecosystem associations of the mid-coast drier transitional coastal western hemlock zone (CWHh) in the lower Kimsquit valley

Symbol	Common name	Number of variations[1]
1	Dry Douglas-fir-shore pine-moss-lichen	4
II	Submesic hemlock-moss	1
III	Zonal hemlock-(Douglas-fir) -Vaccinium-moss	1
IV	Moist oak fern-moss	2
V	Devil's club-fern	4
VI	Flood plain spruce-devil's club	10
VII	Skunk cabbage swamp	1
VIII	Avalanche tracks (associations undefined)	None defined
IX	Nonforested freshwater wetlands (associations undefined)	None defined

[1]Variations differ in species composition from the orthic climax association and reflect different site histories or successional stages.

Most of the ecosystem associations are represented mainly by young climax to old-growth development stages. On the lower flood plain, however, fluvial disturbances as well as logging that occurred around 1918 have resulted in the dominance of pioneer seral to mature seral development stages of the flood plain spruce-devil's club and devil's club-fern associations. Herb- and shrub-dominated pioneer seral stages of zonal hemlock-Vaccinium-moss, moist oak fern (Gymnocarpium dryopteris)-moss, and devil's club-fern associations have resulted from recent logging activities along the west side of the valley, including some higher terraces of the flood plain.

We described 14 landform/soil types within the study area and have summarized these in table 3. Some associations are restricted to just one or two landform/soil types, whereas others occur on several. For example, the flood plain spruce-devil's club association occurs only on active and inactive flood plains (F1 and F2) with mainly regosolic and brunisolic soils. The zonal hemlock-Vaccinium-moss association, on the other hand, occurs on 10 of the 14 landform/soil types including morainal, colluvial, fluvial, fluvial-glacial, and glaciolacustrine landforms, where Podzols and Brunisols are the predominant soils. The ecosystem association, successional stage, and variation, together with landform/soil type, thus convey quite specific habitat information.

Table 3.--Synopsis of landform/soil types in the CWHh of the lower Kimsquit valley

Symbol	Name	Dominant soil great group[1]	Dominant humus form[2]	Particle size class[3]	Slope position and range	Associated ecosystem associations[4]	No. of plots
C1	Rubbly-bouldery colluvium	HFP, DYB, FO	HMR, LMR	CLS, SS, CL	Upper to lower slopes; 25-85 pct	II, VIII, IV, (V, III, I)	14
C2	Cobbly colluvium	HFP, FHP, SB, DYB	HMR, HUMR, MMR	CLS, SS	Upper to lower slopes; 15-75 pct	II, VIII, III, IV, V, (I)	24
C3	Fine colluvium	HFP, DYB, FHP	HMR, LMR, MLR	CL, S	Upper to lower slopes; 30-65 pct	II, IV, VIII, (III)	8
F1	Active fluvial level	R, DYB	VMR, MMR, LMR, VOR	S, FL, SS, CLS	Level; 0 pct	VI, (IX, V, VII)	39
F2	Inactive fluvial level	DYB, R, HFP	LMR, HMR, MMR	S, SS, FL	Level; 0 pct	V, VI, IV, (III, VII)	39
F3	Fluvial fans	HFP, DYB	HUMR, HMR, LMR, MMR	SS, S, FL, CLS	Lower slopes and toes; (midslopes); 0-35 pct	V, (III, IV, VI, VII)	22
G1	Fluvialglacial terraces	HFP	HUMR, HMR	CL, S	Lower slopes and level; 0-75 pct	III, (VII)	5
G2	Fluvialglacial deltas	HFP	HMR, XMR	S,SS	Upper to lower slopes and level; 0-70 pct	II, I	4
G3	Fluvialglacial deltas with cemented horizons	HFP	HUMR, HMR	CL, SS	Upper to lower slopes: 0-5 pct	III, I	2
L1	Glaciolacustrine	DYB, FHP	HMR, HUMR	C, Si	Midslope to level; 0-50 pct	III, IV, V	4
M1	Morainal	HFP, FHP, DYB	HMR, HUMR	CL, S, SS, LS	Mid to lower slopes; 5-75 pct	III, (V, II, IV, VII)	20
M2	Morainal with cemented horizons	HFP, FHP	HMR	CL, FL	Mid to lower slopes; 5-55 pct	III	3
O1	Wetland organic deposits	M, H, F	HIMR, HYMR, SML	Organic	Toeslopes; depressions; level	VII, IX	7
R1	Exposed bedrock and shallow soils over rock	FO, HFP, NS	XMR, HUMR, HMR, MMR, VMR	F, S, SS	Crests to midslopes; 20-80 pct	I, II	8

[1]Soil taxonomy follows Canada Soil Survey Committee (1978). Abbreviations: DYB, Dystric Brunisols; F, Fibrisols; FHP, Ferro-Humic Podzols; FO, Folisols; H, Humisols; HFP, Humo-Ferric Podzols; M, Mesisols; NS, non-soils; R, Regosols; SB, Sombric Brunisols.
[2]Humus form taxonomy follows Klinka and others (1981). Abbreviations: HMR, Hemimor and Hemihumimors; HIMR, Histomoder; HUMR, Humimors; HYMR, Hydromors; LMR, Leptomoders; MLR, Mullmoders; MMR, Mormoders; SML, Saprimulls; VMR, Velomoders; VOR, Velomors; XMR, Xeromors.
[3]Particle size classes follow Canadian Soil Survey Committee (1978). Abbreviations: CL, coarse loamy; CLS, coarse loamy skeletal; F, fragmental; FL, fine loamy; S, sandy; Si, silty; SS, sandy skeletal.
[4]Ecosystem associations as follows: (I) dry Douglas-fir-shore pine-*Vaccinium*-(salal)-moss-lichen; (II) submesic hemlock-moss; (III) zonal hemlock-(Douglas-fir)-*Vaccinium* moss; (IV) moist oak fern-moss; (V) devil's club-fern; (VI) flood plain spruce-devil's club; (VII) skunk cabbage swamps; (VIII) avalanche tracks; (IX) nonforested freshwater wetlands.

A table of prominence values (table 4) summarizes the climax and seral classification of the study area. This is not a complete species list but includes those species with prominence values of 50 or more in at least one unit, as well as known grizzly bear food species and some important character species of minor occurrence. Table 4 provides a quick comparison of species composition among the associations and variations. Associations are arranged from left to right along a gradient of increasing soil moisture.

Ordination of Vegetation Data

We performed several DECORANA (Hill 1979) ordinations on different subsets of the data. Ordinating vegetation data that are also being classified is useful for visually displaying the variability represented by the sample plots and illustrating relationships among ecosystem units. The most useful ordinations were obtained by subdividing the samples into forested and nonforested communities. Only the ordination of forested communities is presented here (fig. 4). Forested communities include mature seral to old-growth stages of all ecosystem associations and exclude the nonforested wetlands and avalanche tracks. The scatter diagram shows sample scores along the first two ordination axes. These two axes account for most of the variation in the data, but it is important to keep in mind that third and higher axes exist that further differentiate the samples.

We classified the releves by subjective tabular comparison before performing the ordinations; the ecosystem association and successional stage to which each sample was assigned are indicated in fig. 4. As a result of the ordinations, the classification of some releves was reevaluated and in a few cases changed. For the most part, however, the original classification remained intact, and the ordinations mainly served to illustrate the relative distinctness of, and variability within, each association.

The ordination of forested communities (fig. 4) illustrates that some associations are quite distinct, whereas others overlap with closely related associations. Samples of the driest Douglas-fir-shore pine association (I) form a tight cluster on the extreme left. The submesic hemlock-moss (II) and the zonal hemlock-Vaccinium -moss associations (III) show some overlap. Species composition is similar in these two associations (table 4), and they are distinguished more on the basis of productivity of the tree layers and relative abundance of several understory shrubs and herbs. The moist oak fern-moss (IV) and devil's club-fern (V) associations are also closely related. Again, these associations differ mainly in the relative dominance of a few species such as Oplopanax horridus and Gymnocarpium dryopteris. The alluvial spruce association (VI) is clearly separated from all other associations except V. The mature seral stands of association VI, dominated by red alder and black cottonwood,

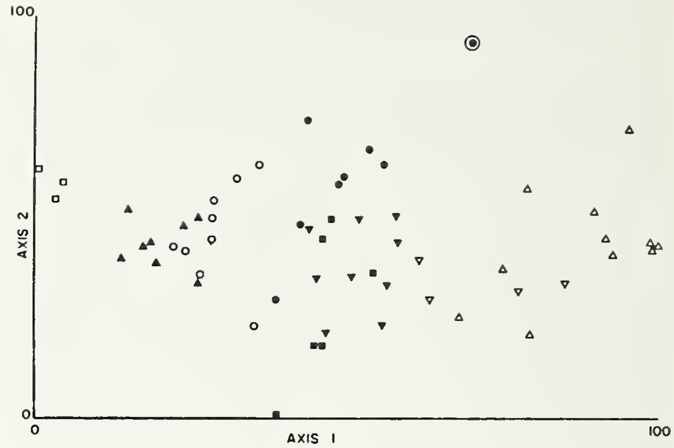

Figure 4.--DECORANA ordination of mature seral to old-growth forest communities. Association symbols: (□) dry Douglas-fir-shore-pine-moss-lichen, mature climax; (▲) submesic hemlock-moss, mature climax; (○) zonal hemlock-Vaccinium-moss, mature climax; (■) moist oak fern-moss, mature climax to old-growth; (▼) devil's club-fern, mature climax to old growth; (▽) flood-plain spruce-devil's club, mature climax to old-growth; (△) flood plain spruce-devil's club, mature seral; (●) skunk cabbage swamp, mature climax; (◉) skunk cabbage swamp, mature seral.

occur on the far right and the climax and old-growth, spruce-dominated stands ordinate adjacent to the V samples. The cluster of mature climax cedar-skunk cabbage swamp (VII) samples suggests some vegetative similarities to associations IV and V. The high cover of Lysichiton americanum, however, distinguishes VII samples from those of the other associations. The mature seral VII sample is distinctive in its domination by red alder.

The ordination of forest communities in figure 4 can be interpreted qualitatively in terms of several ecosystem characteristics. Species diversity is lowest in association I on the far left; increases to a maximum in the center (V and VII); and then declines slightly in the VI samples on the right (see table 4). As we would expect, the associations with higher species diversity are also the most variable. The highest diversity of grizzly bear food species occurs in the ecosystems on the right-hand side of the ordinations (V, VI, VII). There is a general trend of increasing forest productivity from left to right on the ordination diagram. This most likely reflects a complex gradient of increasing moisture and nutrient availability mainly along the first ordination axis.

Ecosystem Mapping

We mapped 419 polygons as pure or complex units within the 5 000 ha study area and field-checked 55 percent of these in at least one location. On the lower flood plain and on the west side of the valley where access was easiest, vegetation

Table 4.--Species prominence values[1] for successional stages and variations of ecosystem associations in the CWHh of the lower Kimsquit Valley

Strata and species	I[2]		II		III				IV			V	VI											VII		VIII		IX
	[3]F-G	A [4]1	F-G	C 1	F-H	F-H 2	D-F 3	C 4	F-H	F-G 1	C 2	F-H	F-H	E-F 1	E 2	E 3	E 4	D 5	D 6	D 9	D 10	C 7	B-D 8	G	E 1	C	B	G
TREE LAYERS:																												
Tsuga heterophylla	104		305		370	275	454		168	550		215	90	48		17	2					6		220	50			
Abies amabilis				70	147	320	83		121	18		93	35	10		T								14				
Thuja plicata			80		44		107		259	595		182	37	108		14					50	10		320	50			
Pseudotsuga menziesii	80		120		19		117		57	255		90				4					100			13				
Picea sitchensis			11				71		38	71		66	310	367		86	43			14	200	14	18	116	100	7		
Pinus contorta	143																											
Populus balsamifera ssp. trichocarpa												2	68	350	450	427	41		150	675	150							
Alnus rubra									5				19	10	50	195	550	800	100	550			53	5	200			
SHRUB LAYERS:																												
Tsuga heterophylla	275	20	103	80	160	135	30	50	57	195	19	102	23	22			22		10	28	50	8	130	200	50	4	7	
Abies amabilis	7		68		156	125	17	200	28	35	23	25	16	20			1			14		4		110	50			
Thuja plicata	55		36	10	13		25		15	105		24	1			3				35	50		55	10	50	7		
Picea sitchensis		20							5				2	8	50	36	35	5	70	85	50	19	175	10	50			
Pinus contorta	53																		5									
Populus balsamifera ssp. trichocarpa																			500				175			3		
Alnus rubra													16	4				50	450				325		100			
Acer glabrum									T	4		T							20			2		T		120		
Alnus viridis ssp. sinuata																7			100	14				2		80		
Salix sitchensis																			150	11		8	55			209	135	
Vaccinium alaskaense*	145		152	150	270	300	65		77	28	10	50	19	2		T					10	6		106	30			
Vaccinium ovalifolium*	7		80	150	170	250	6	350	30	28	127	38				2				11		8	2	132	20	2		
Menziesia ferruginea	27		67	50	100	45		40	10		8	10											4	64		2		
Vaccinium parvifolium*	63		73	150	10	4	25		15	28	4	5				2				11			2	13				
Oplopanax horridus*					T		1		30	18	33	186	350	333	990	163	272			21	100	83		100	150	198	16	
Rubus spectabilis*								20	8		136	30	123	173	600	345	483	100	10	300	50	167		32	700	113	27	71
Rubus parviflorus*				10					T	4	87	55	76	200	250	288	17		40	250	150	167	178	25		66	283	
Sambucus racemosa*				10					T		68	4	12	27	50	115	283					55				19	19	
Cornus sericea										2	65	6	14			4		50	30	75	100	173	53	54	50	71	4	
Viburnum edule*									4	4	4	12	18	10		59			20	150	200	36	4	39	100	54		
Ribes bracteosum*												T	T		50	7	35				50			T	50	24	14	
Lonicera involucrata*															50	80	16	50	50	175	50			6		T	53	
Spirea douglasii																										T	350	
HERB LAYER:																												
Cornus canadensis	2		13	80	9	85	T	50	15	42	38	11		1		3					10	33		25				
Clintonia uniflora			8	50	5	30	3	80	16	42	16	22	8	2		2						10		14		2		
Goodyera oblongifolia	T		50		6		3	5	2	23		2									5			T				
Dryopteris assimilis*			T		2	2			37		22	24	24	2	20	2	4					10		T		18	4	
Streptopus roseus			T		T	2	T		42	53	6	34	26	118	5	8	7			11	10	22		29		21	11	
Tiarella unifoliata					T		T		4		80	4	5	2		2	1			2	10	43	2	17				
Gymnocarpium dryopteris						2	3		181	45	43	161	182	58	5	3	2			23	200	17		36	5	5		
Pteridium aquilinum			1	20								T												13		42	473	
Athyrium filix-femina*			T						5	2	204	46	76	42	50	37	53	5		18	50	417		138	50	150	317	18
Circaea alpina									4		30	4	35			2	3	50				60		T		3		2
Carex sitchensis(*)																												250
Calamagrostis canadensis(*)												4								50						T	40	53
Disporum hookeri									2	55	4	13	12	11	5	9	4			4	10	4				10	41	
Polystichum munitum									1	100		6										1						
Osmorhiza spp.*										2		T		6	5	9			20	4	10			T				
Phalaris arundinacea(*)																												53
Elymus glaucus(*)																2			300	18		1	4					
Trautvetteria caroliniensis													12	161	183	300	64	103	150		60	150	2		2	T	11	18
Maianthemum dilatatum									T			3	2	65	5	23	3			35	10	1	2			5	27	
Urtica dioica													T	1		3	1									5	87	
Lysichiton americanum*												6	13									19		360	250	7		2
Equisetum arvense*												T				7	1	50		4				5		2		28
Scirpus microcarpus																		50							5			141
Aruncus dioicus													1		50			20		30			2			T	41	
Festuca subulata(*)																		5	50							3	6	
Heracleum sphondylium*																		5								4	112	

(con.)

Table 4. (Con.)

Strata and species	I[2] [3]F-G	I A [4]1	II F-G	II C 1	III F-H	III F-H 2	III D-F 3	III C 4	IV F-H	IV F-G 1	IV C 2	V F-H	VI F-H	VI E-F 1	VI E 2	VI E 3	VI E 4	VI D 5	VI D 6	VI D 9	VI D 10	VI C 7	VI B-D 8	VII G	VII E 1	VIII C	VIII B	IX G
BRYOPHYTE AND LICHEN LAYER:																												
Rhytidiadelphus loreus	18		150		350	425	38	100	154	120	16	83	37	2	5			T	30	7		50	4	80		3		
Hylocomium splendens	83		400	450	180	53	37	100	59	170	10	56		2					50			1	18	89				
Rhytidiopsis robusta	20		101		57	225	53		7			13												T				
Mnium glabrescens					T				29			49	14	2		5						1		240		44	14	
Mnium insigne							1		16	18		41	84	35	5	30	27			11	50			T		19		
Rhacomitrium heterostichum		300																										
Cladonia spp.	89	170																	10				18					
Stereocaulon spp.	27	100																	20				35					
Rhacomitrium canescens	13	50																	400				325					
Pleurozium schreberi	475	30	56	150																			4	9				
Polytrichum juniperinum																			100				75					
Drepanocladus spp.																												88
Average cover (percent) of strata																												
Tree	38	0	58	0	65	60	82	0	75	83	0	73	55	70	50	63	65	85	15	78	50	5	13	50	40	6	0	5
Shrub	60	5	66	30	84	80	7	40	31	30	58	54	70	74	100	96	100	95	65	68	85	57	83	69	95	83	34	75
Herb	13	0	9	15	9	10	3	12	42	40	52	49	73	55	43	25	20	40	35	10	60	67	7	68	30	49	100	58
Bryophyte and lichen	88	50	85	65	74	80	15	20	33	40	9	42	25	14	1	6	3	5	50	2	10	11	50	72	25	12	4	25
[5]	4	1	7	1	5	2	3	1	5	2	3	9	5	3	1	4	3	1	1	2	1	3	2	5	1	4	3	2

[1]Prominence value = mean cover x $\sqrt{\text{frequency}}$. Only species with prominence values of 50 or more in at least one unit are included in the table (except for a few grizzly bear food species). Known grizzly bear food species are marked with an asterisk [*]. Uncertain food species are marked with a parenthetical asterisk [(*)].

[2]Ecosystem associations as follows: (I) dry Douglas-fir-shore pine-moss-lichen; (II) submesic hemlock-moss; (III) zonal hemlock-(Douglas-fir)-Vaccinium moss; (IV) moist oak fern-moss; (V) devil's club-fern; (VI) flood plain spruce-devil's club; (VII) skunk cabbage swamps; (VIII) avalanche tracks; (IX) nonforested freshwater wetlands.

[3]Successional stages as follows: (A) nonvegetated or bryoid; (B) herb pioneer seral; (C) shrub - seedling pioneer seral; (D) pole - sapling; (E) mature seral; (F) young climax; (G) mature climax; (H) old growth.

[4]Variations of ecosystem associations as follows: I(1), Rhacomitrium-lichen; II(1), Vaccinium-bunchberry; III(2), amabilis fir-Rhytidiopsis; III(3), nudum; III(4), Vaccinium-queen's cup; IV(1), sword fern; IV(2), Rubus-oak fern; VI(1), cottonwood-spruce-salmonberry-devil's club; VI(2), cottonwood-devil's club; VI(3), cottonwood-alder-salmonberry-devil's club; VI(4), alder-salmonberry-elderberry; VI(5), alder-salmonberry; VI(6), alder-grass; VI(7), salmonberry-lady fern; VI(8), alder-willow-fireweed-Rhacomitrium riverbar complex; VI(9), cottonwood-alder-twinberry; VI(10), spruce-cottonwood-thimbleberry; VII(1), alder-salmonberry.

[5]Number of releves (total = 84).

patterns most complex, and grizzly bear activity the highest, we field-checked 80 percent of the polygons.

Area summaries by ecosystem unit were produced for the portion of the map that was digitized and entered onto the CAPAMP system (90 percent of the 5 000 ha map area; 351 polygons). Figure 5 summarizes map area percentages for each association. The climatic climax or zonal association (III) covers the largest area, followed by the submesic hemlock-moss association (II). Together these two associations comprise over 50 percent of the digitized map.

The flood plain spruce-devil's club (VI) and the devil's club-fern (V) associations cover significant portions of the map area (17 and 11 percent, respectively) and show abundant evidence of grizzly activity (see Hamilton and Archibald this volume). Skunk cabbage swamps (VII), avalanche tracks (VIII) and nonforested wetlands (IX) cover less than 3 percent of this lower elevation map area. Although of minor extent, these ecosystems provide important grizzly bear habitat.

Classification and Mapping of Flood Plain Communities

A discussion of the flood plain spruce-devil's club ecosystem association and its 10 seral variations will serve as a working example of our approach to the classification and mapping of seral ecosystems. Flood plain ecosystems are among the most important grizzly bear habitats in the study area, partly because of their proximity to the salmon spawning channels of the Kimsquit River but also because of the diversity of grizzly food plants that grow in flood plain communities. The complex mosaic of seral stages belonging to the flood plain spruce-devil's club association also presented the greatest challenge for classification and mapping.

Table 4 summarizes the vegetative features of the flood plain spruce-devil's club climax association and the 10 seral variations that we

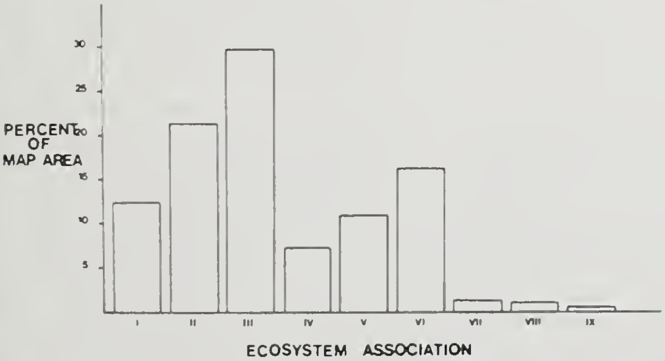

Figure 5.--Percentage of digitized map area covered by each ecosystem association. Association symbols: (I) dry Douglas-fir-shore pine-moss-lichen; (II) submesic hemlock-moss; (III) zonal hemlock-*Vaccinium*-moss; (IV) moist oak fern-moss; (V) devil's club-fern; (VI) flood plain spruce-devil's club; (VII) skunk cabbage swamp; (VIII) avalanche tracks; (IX) nonforested freshwater wetlands.

recognized. Table 5 summarizes selected site factors. Figure 6 illustrates the relative extent of each of the flood plain spruce variations for the digitized portion of the map.

Pioneer seral development stages on the flood plain are represented by two variations: the salmonberry (*Rubus spectabilis*)-lady fern (*Athyrium filix-femina*) variation (7) and the alder-willow (*Salix* spp.)-fireweed (*Epilobium* spp.)-*Rhacomitrium* variation (8). These two variations exemplify early succession on fluvial substrates of contrasting textures and moisture/nutrient regimes (table 5). The alder-willow-fireweed-*Rhacomitrium* variation develops where severe and repeated disturbance by fluvial scouring and deposition creates freshly exposed, coarse-textured, and usually dry substrates. It is thus widespread along the active portions of the flood plain. The salmonberry-lady fern variation apparently results from less severe disturbances such as windthrow or logging that remove the tree canopy but enhance the growth of invader or residual understory species. This variation comprised less than 1 percent of the area mapped as the flood plain spruce-devil's club association.

Many alluvial soils have fine-loamy surface horizons overlying gravelly horizons at depth. On parts of the lower Kimsquit flood plain, recent, severe logging disturbance has removed or disturbed this fine-textured surface horizon, reducing site productivity to the extent that secondary succession is similar to that

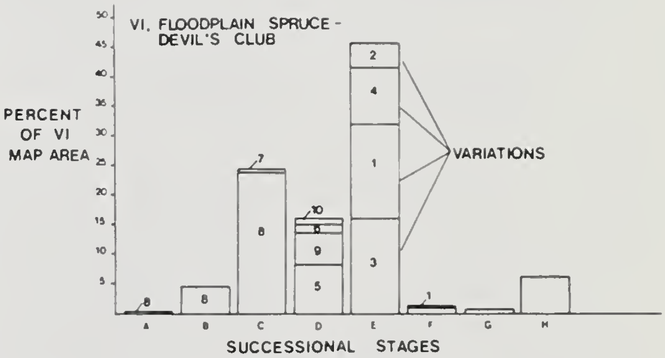

Figure 6.--Percentage of flood plain-spruce devil's club map area covered by each successional stage and variation. Successional stage designations: (A) nonvegetated or bryoid; (B) herb pioneer seral; (C) shrub-seedling pioneer seral; (D) pole-sapling; (E) mature seral; (F) young climax; (G) mature climax; (H) old-growth. Variation designations: (1) cottonwood-spruce-salmonberry-devil's club; (2) cottonwood-devil's club; (3) cottonwood-alder-salmonberry-devil's club; (4) alder-salmonberry-elderberry; (5) alder-salmonberry; (6) alder-grass; (7) salmonberry-lady fern; (8) alder-willow-fireweed-Rhacomitrium; (9) cottonwood-alder-twinberry; (10) spruce-cottonwood-thimbleberry. Bars without numbers represent orthic climax vegetation for the association.

Table 5.--Synopsis of the flood plain spruce-devil's club ecosystem association and its seral variations in the CWHh of the lower Kimsquit valley

Ecosystem variation No.	Common name	Successional stage	Age (years)	Ecological moisture regime[1]	Soil subgroup[2]	Humus form[3]	Particle size class[4]	No. of plots
VI	Orthic vegetation	Young climax-old growth (F-H)	85-200+	Mesic-subhygric	GL.DYB, O.DYB, O.R, GLCU.R	MMR	S, SS, CL	8
VI(1)	Cottonwood-spruce-salmonberry-devil's club	Mature seral-young climax (E-F)	40- 88	Subhygric	O.DYB, GL.DYB, GL.R, GLCU.R	LMR, MMR VML, VMR	S, SS, CL, FL	8
VI(2)	Cottonwood-devil's club	Mature seral (E)	52- 65	Subhygric	O.SB	MLR	CL	1
VI(3)	Cottonwood-alder-salmonberry-devil's club	Mature seral (E)	45- 67	Mesic-subhygric	O.R, CU.R, GL.R	LMR, VMR MMR	S, SS, CL	8
VI(4)	Alder-salmon-berry-elderberry	Mature seral (E)	30- 60	Subhygric	GL.DYB, O.DYB O.R, CU.R	VMR, LMR VOR, MMR	S, SS, CL	14
VI(5)	Alder-salmon-berry	Pole-sapling (D)	8- 10	Subhygric	GLCU.R	VMR, RML	FL, CL	3
VI(6)	Alder-grass	Pole-sapling (D)	5- 25	Submesic	O.R, O.SB	VOR, RML	S, SS, CLS	3
VI(7)	Salmonberry-lady fern	Shrub-seedling pioneer seral (C)	5- 15	Subhygric	GL.EB, GL.HFP	LMR	S, FL	1
VI(8)	Alder-willow-fireweed-_Rhacomitrium_ river bar complex	Herb/shrub seedling pioneer seral and pole-sapling (A-C)	20- 40	Submesic-mesic	O.R	XMR, VMR	SS	2
VI(9)	Cottonwood-alder-twinberry	Pole-sapling (D)	20- 35	Mesic-subhygric	O.R, CU.R, GLCU.R	VMR	S	4
VI(10)	Spruce-cottonwood-thimbleberry	Pole-sapling-mature seral (D-E)	30- 50	Mesic	O.R	LMR	S	1

[1]Ecological moisture and nutrient regimes are a subjective assessment of relative moisture and nutrient availability (Pojar 1983).
[2]Soil taxonomy follows Canada Soil Survey Committee (1978). Abbreviations: CU.R, Cumulic Regosols; GLCU.R, Gleyed Cumulic Regosols; GL.DYB, Gleyed Dystric Brunisols; GL.EB, Gleyed Eutric Brunisols; GL.HFP, Gleyed Humo-Ferric Podzols; GL.R, Gleyed Regosols; O.DYB, Orthic Dystric Brunisols; O.R, Orthic Regosols; O.SB, Orthic Sombric Brunisols.
[3]Humus form taxonomy after Klinka and others (1981). Abbreviations: HMR, Hemimors and Hemihumimors; LMR, Leptomoders; MLR, Mullmoders; MMR, Mormoders; RML, Rhizomulls; VMR, Velomoders; VOR, Velomors; XMR, Xeromors.
[4]Particle size classes follow Canada Soil Survey Committee (1978). Abbreviations: CL, coarse-loamy; CLS, coarse-loamy skeletal; FL, fine-loamy; S, sandy; SS, sandy-skeletal.

occurring on the coarse-textured gravel bars. The nature and severity of disturbance thus has a large bearing on secondary succession.

We described four pole-sapling variations of the flood plain spruce association. These are: alder-salmonberry (5), alder-grass (6), cottonwood-alder-twinberry (Lonicera involucrata) (9), and spruce-cottonwood-thimbleberry (Rubus parviflorus) (10). The alder-salmonberry variation has been mapped as a variation of both the flood plain spruce and devil's club-fern associations. It is the wettest young-seral variation and represents 8- to 10-year-old, dense alder stands on fine-loamy to loamy Gleyed Cumulic Regosols with Moder and Mull humus forms. This community typically occurs adjacent to meandering back channels and as a result may be subject to frequent flooding.

The alder-grass variation is relatively uncommon but occurs on some gravelly, often compacted, alluvial deposits. The origin of this community is unclear, but it was sometimes found on what appeared to be old skid trails and it may reflect soil disturbance and compaction resulting from logging in the early 1900's. This variation may also represent further successional development from the alder-willow-fireweed-Rhacomitrium variation.

Both the cottonwood-alder-twinberry variation and the spruce-cottonwood-thimbleberry variation are found on Regosols developed in sandy fluvial materials. These variations occur predominantly upstream of the early logging, and they probably originated from more recent fluvial disturbances that left behind fine-textured materials (sands rather than gravels). Spruce-cottonwood-thimbleberry is the drier of these two variations and is dominated by conifers (Sitka spruce, Douglas-fir, and redcedar), whereas the more widespread cottonwood-thimbleberry variation is mainly deciduous, with conifers in the understory. This may partially reflect the differences in age between these two variations (table 5), but other factors such as seed sources, soil moisture, and site history have undoubtedly influenced species composition as well.

The four mature seral variations of the flood plain spruce association are: cottonwood-spruce-salmonberry-devil's club (1), cottonwood-devil's club (2), cottonwood-alder-salmonberry-devil's club (3), and alder-salmonberry-elderberry (Sambucus racemosa) (4). Two of these (1 and 4) have also been mapped as seral variations of the devil's club - fern association. These four mature seral variations make up almost 50 percent of the flood plain spruce-devil's club map area (fig. 6) and probably represent stands established after the 1918 logging.

A comparison of these four variations in table 5 reveals only minor differences in moisture/nutrient regimes, soil subgroups, humus forms, and soil particle size. Variation in species composition must therefore be explained by other factors such as age of the stand, disturbance regimes, seed sources, species composition before disturbance, and chance. Unfortunately, we lack information on all of these factors except age.

Cottonwood-spruce-salmonberry-devil's club is the oldest of the four variations (40 to 88 years). Some examples of this variation were classified as young climax because they contained significant amounts of spruce and other conifers in both the overstory and understory.

The data illustrate that the relative amounts of Alnus rubra and Populus trichocarpa in seral communities are at least partially related to maturity of the stand. Most seral communities contain both species but the youngest examples of mature seral variations are dominated by Alnus (4) and the oldest by Populus (1 and 2). These two species appear to have similar ecological requirements and tolerences in flood plain habitats, and both are prolific seed producers (Fowells 1965). Populus, however, reproduces vegetatively (by suckers as well as sprouts) more effectively than Alnus (which does not produce suckers). In addition, Populus is a longer living and taller species. Although the proportions of these two species in early and midsuccessional stages may be determined by site history and chance, and both species are characterized by high initial growth rates, Populus is able to maintain height growth longer and eventually dominate these seral stands as they approach maturity.

Only localized areas of climax and old-growth alluvial forests remain in the lower Kimsquit valley (fig. 6). These impressive forests are dominated by Sitka spruce and usually contain other coniferous species as well as scattered mature individuals of black cottonwood.

CONCLUSIONS

We developed an approach to ecosystem classification and mapping that links structural development stages and present species composition to a climax-based biogeoclimatic classification. The three levels of ecosystem generalization (the ecosystem association, successional stage, and variation) together with the landform/soil units form a useful framework for evaluating coastal grizzly bear habitat (Hamilton and Archibald this volume). Derivative maps for specific habitat interpretations can be produced using one or more of these classification levels depending on the required detail. Habitat ratings for some activities such as feeding, may require specific information on species composition; this is provided at the level of ecosystem variation. The successional stage category, on the other hand, provides sufficient information for other habitat interpretations such as cover. For broad-scale habitat evaluations of entire watersheds, a map of associations or groups of related associations and seral stages may be all that is required. A computer-assisted mapping system facilitates the rapid production of such derivative maps.

REFERENCES

Alaback, P.B. Plant succession following logging in the Sitka spruce-western hemlock forests of Southeast Alaska: implications for management. Gen. Tech. Rep. PNW-173. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1984. 28 p.

Archibald, W.R.; Hamilton, A.N. Working plan, coastal grizzly research project. 1982. Unpublished report on file at: British Columbia Ministry of Environment, Wildlife Branch. Victoria, BC. 25 p.

Arno, S.F. Classifying forest succession on four habitat types in western Montana. In: Means, J.E., ed. Forest succession and stand development research in the Northwest. Corvallis, OR: Oregon State University, Forest Research Laboratory; 1982: 54-62.

Baer, A.J. Bella Coola-Laredo Sound map areas, British Columbia. Memoir 372. Ottawa, ON: Department of Energy Mines and Resources, Geological Survey of Canada; 1973. 122 p. plus maps.

Banner, A. Ecosystem classification and mapping in the Coastal Western Hemlock Zone Mid-Coast Drier Transitional Subzone (CWHh), Kimsquit River Valley, British Columbia. 1985. Unpublished report on file at: British Columbia Ministry of Forests, Smithers, BC. 100 p.

Canada Soil Survey Committee. The Canadian system of soil classification. Publication 1646. Ottawa, ON: Canada Department of Agriculture, Research Branch; 1978. 164 p.

Clement, C. Biogeoclimatic units and ecosystem associations of the Kimsquit drainage. 1984a. Unpublished contract report on file at: British Columbia Ministry of Environment, Wildlife Branch. Victoria, BC. 93 p.

Clement, C. Habitat types of the Kimsquit River estuary. 1984b. Contract report on file at: British Columbia Ministry of Environment, Wildlife Branch. Victoria, BC. 27 p.

Craighead, J.J.; Sumner, J.S.; Scaggs, G.B. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Wildlife-Wildlands Institute Monograph 1. Missoula, MT: University of Montana; 1982. 279 p.

Crum, A.H.; Steere, W.C.; Anderson, L.E. A new list of mosses of North America north of Mexico. Bryologist. 76: 83-130; 1973.

Environment Canada. Canadian climate normals, 1951-1980. Temperature and precipitation, British Columbia. Downsview, ON: Environment Canada, Atmospheric Environment Service; 1980. 268 p.

Fowells, H.A. Silvics of forest trees of the United States. Agriculture Handbook 271. Washington, DC: U.S. Deptartment of Agriculture, Forest Service; 1965. 762 p.

Hale, M.E.; Culberson, W.L. A second checklist of the lichens of the continental United States and Canada. Bryologist. 63: 137-172; 1970.

Hamer, D.; Herrero, S., Eds. Ecological studies of the grizzly bear in Banff National Park. 1978. Parks Canada contract report WR-4-80. Calgary, AB: University of Calgary; 1983. 303 p.

Hamilton, A.N. Progress report, coastal grizzly research project, year 1 (1982). 1983. Unpublished report on file at: British Columbia Ministry of Environment, Wildlife Branch, Victoria, BC. 32 p.

Henderson, J.A. Succession on two habitat types in western Washington. In: Means, J.E., ed. Forest succession and stand development research in the Northwest. Corvallis, OR: Forest Research Laboratory, Oregon State University; 1982: 80-86.

Hill, M.O. DECORANA -- a fortran program for detrended correspondence analysis and reciprocal averaging. Ithaca, NY: Cornell University, Ecology and Systematics; 1979. 30 p.

Holland, S.S. Landforms of British Columbia. A physiographic outline. Bulletin 48 (2d ed.). Victoria, BC: British Columbia Department of Mines and Mineral Resources; 1976. 138 p.

Houseknecht, S.J. Vegetational composition and regeneration in three forest associations after logging in the Coastal Western Hemlock Zone. Vancouver, BC: University of British Columbia; 1976. 224 p. M.Sc. thesis.

Huschle, G.; Hironaka, M. Classification and ordination of seral plant communities. Journal of Range Management. 33(3): 179-182; 1980.

Inselberg, A.E.; Klinka, K.; Ray, C. Ecosystems of MacMillan Park on Vancouver Island. Land Management Report 12. Victoria, BC: British Columbia Ministry of Forests; 1982. 113 p.

Jungen, J.R.; Lewis,T. The coast mountains and islands. In: Valentine, K.W.G.; Sprout, P.N.; Baker, T.E.; Lavkulich, L.M., eds. The soil landscapes of British Columbia. Victoria, BC: British Columbia Ministry of Environment, Resource Analysis Branch; 1978: 101-120.

Klinka, K.; Phelps, S. Environment vegetation tables by a computer program. 1979. Unpublished report on file at: University of British Columbia, Faculty of Forestry. Vancouver, BC. 24 p.

Klinka, K.; Green, R.N.; Trowbridge, R.L.; Lowe, L.E. Taxonomic classification of humus forms in ecosystems of British Columbia. First Approximation. Land Management Report 8. Victoria, BC: British Columbia Ministry of Forests; 1981. 54 p.

Klinka, K.; Scagel, A.M.; Courtin, P.J. Vegetation relationships among some seral ecosystems in southwestern British Columbia. Canadian Journal of Forest Research. 15:561-569; 1985.

Krajina, V.J. Biogeoclimatic zones and biogeocoenoses of British Columbia. Ecology of Western North America. 1: 1-17; 1965.

Meidinger, D.V.; Hamilton, E.; Fleming, T. Data processing system users guide; ecosystem classification program. Version 1. 1983. Unpublished report on file at: British Columbia Ministry of Forests, Research Branch, Victoria, BC. 80 p.

Mueller-Dombois, D. The Douglas-fir forest associations on Vancouver Island in their initial stages of secondary succession. Vancouver, BC: University of British Columbia; 1959. 570 p. Ph.D. dissertation.

Pojar, J., comp. and ed. Forest ecology. In: Watts, S., ed. Forestry handbook for British Columbia (4th ed.). Vancouver, BC: University of British Columbia, Forestry Undergraduate Society; 1983: 221-318.

Stotler, R.; Crandall-Stotler, B. A checklist of the liverworts and hornworts of North America. Bryologist. 80: 405-428; 1977.

Taylor, R.L.; MacBryde, B. Vascular plants of British Columbia: a descriptive resource inventory. Technical Bulletin 4. Vancouver, BC: University of British Columbia, The Botanical Garden; 1977. 754 p.

Thomas, J.W., ed. Wildlife habitats in managed forests: the Blue Mountains of Washington and Oregon. Agriculture Handbook 553. Washington DC: U.S. Department of Agriculture, Forest Service; 1979. 512 p.

Walmsley, M.;Utzig, G.; Vold, T.; Moon, D.; van Barneveld, J., eds. Describing ecosystems in the field. RAB Technical Paper 2/Land Management Report 7. Victoria, BC: British Columbia Ministry of Environment/Ministry of Forests; 1980. 224 p.

Westhoff, V.; van der Maarel, W. The Braun-Blanquet approach. In: Whittaker, R.H., ed. Classification of plant communities. The Hague: Dr. W. Junk; 1978: 287-399.

Yole, D.; Pojar, J.; Robinson, B. Ecosystem classification of the coastal western hemlock zone within the mid-coast timber supply area, Prince Rupert Forest Region, British Columbia. 1982. Unpublished report on file at: British Columbia Ministry of Forests, Smithers, BC. 190 p.

GRIZZLY BEAR HABITAT IN THE KIMSQUIT RIVER VALLEY, COASTAL BRITISH COLUMBIA: EVALUATION

Anthony N. Hamilton and W. Ralph Archibald

ABSTRACT: A grizzly bear (Ursus arctos) habitat evaluation procedure was developed as part of an interagency research project designed to assess the impacts of logging on grizzlies in coastal British Columbia. Discrete habitat units in the Kimsquit River valley were investigated to determine how they meet various bear requirements (feeding, bedding, marking, traveling, denning) on a seasonal, annual, and between-year basis. Specifics of the evaluation procedure, which is based on a mobile ground telemetry system and a detailed grizzly activity site investigation process, are discussed. Preliminary results of the evaluation procedure for a specific activity--feeding--are presented.

INTRODUCTION

The coastal valleys of mainland British Columbia support some of the highest grizzly bear densities in the province. These valleys also produce some of the most valuable timber in B.C. Logging in these valleys coincides with declines in grizzly numbers (Archibald 1983), but it is unknown whether the declines are due to habitat change, excessive hunting during and post logging, or both. The provincial Ministry of Environment, Wildlife Branch, feels that grizzly numbers must be maintained in coastal forests to achieve management objectives. To do so the historical pattern of logging coastal forests with corresponding declines in grizzly populations must be broken.

In April 1982, a research project was begun to provide the information necessary to address the long-term welfare of coastal grizzlies in areas being logged or scheduled for logging. This project is funded and administered cooperatively by the B.C. Ministries of Environment and Forests. Additional funding has been provided by the University of British Columbia and the Canadian Wildlife Federation.

One of the primary objectives of the research is to determine the seasonal habitat requirements of coastal grizzlies. We developed a three-part strategy of habitat classification, mapping, and evaluation to meet this objective. Banner and others (this volume) describe the procedures used to classify and map grizzly bear habitat in the study area. Our paper summarizes the methods we used to evaluate how grizzlies used discrete habitat units to meet their life requisites (feeding, bedding, marking, traveling, and denning) on seasonal, annual, and year-to-year bases. We present preliminary results of the evaluation procedure for feeding to illustrate the results of this strategy thus far.

Grizzly bears in coastal systems differ from most interior and northern populations of grizzlies in that they have access to salmon. Salmon are a readily available, abundant source of meat protein, and play a major role in the feeding habits, movement, behavior, and activity patterns of coastal grizzlies. The impacts of salmon are being documented and will be presented in a future paper.

STUDY AREA

The 50,000-ha study area is the Kimsquit River valley, located 500 km northwest of Vancouver (fig. 1). The topography is rugged, with steep mountains rising abruptly from sea level to over 2 000 m. Hamilton (1984) describes the study area in detail. Habitat classification and mapping of the study area have been completed at a scale of 1:20,000, using the biogeoclimatic system developed by Krajina (1970) (Banner 1985; Clement 1984a,b).

The Kimsquit River goes through a narrow canyon approximately 18 km from the estuary. This canyon conveniently divides the watershed into intensive and extensive areas for study. The intensive area is below the canyon, and ground access is provided by 25 km of logging roads and the navigable river. The extensive area is inaccessible except by aircraft or walking. In this paper, we consider only that portion of the intensive area mapped by Banner and others (this volume).

METHODS

To evaluate how grizzlies used habitat units, we used a data collection strategy that involved capturing and radio-collaring a sample of grizzlies resident to the study area, determining their locations daily, and then conducting site investigations at these locations.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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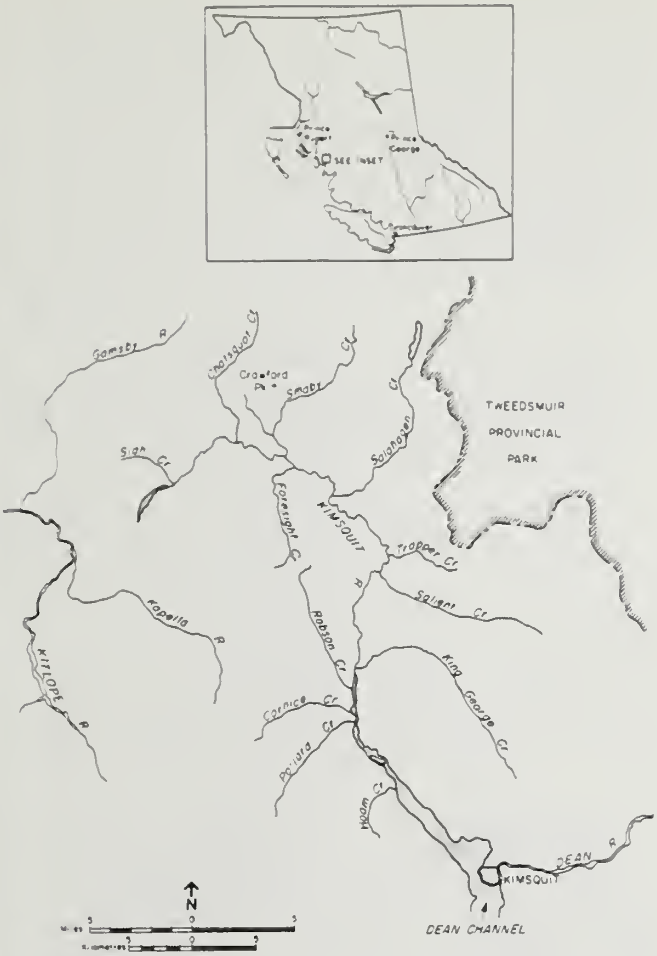

Figure 1.--Location of the Kimsquit River Valley grizzly bear habitat study area.

Capture

We captured grizzlies with Aldrich foot snares in baited cubby sets and trail sets in areas of easy access from the road or river. Transmitter beacons were attached to each snare to permit monitoring of the trapline from a distance (Nolan and others 1984). This procedure improved trapping efficiency and safety for the capture team.

We immobilized captured bears with M99 (etorphine hydorchloride). Immobilized bears were handled using techniques similar to those reported by other researchers (Russell and others 1979; Glen and Miller 1980), and were equipped with radio collars (Telonics, Mesa, AZ).

Radio relocations

Because the success of the data collection strategy depended on reliable locations of bears, we developed a telemetry system that met the following criteria:

1. Allowed for the rapid collection of consecutive bearings.
2. Allowed for field determination of location precision.
3. Protected the receiving equipment from the inclement weather typical of coastal forests.

Twenty-five kilometers of logging roads made possible the development of a vehicle-mounted monitoring system. This system consisted of an elevating antenna mast with a four-element yagi antenna, a dash-mounted magneysn compass, a scanning receiver, and a portable, battery-powered computer with approximately 10K RAM memory (Sharp PC 1500).

The elevating antenna mast was mounted through the cab of the project vehicle so the driver could raise and lower the antenna without leaving his or her seat, and, so the antenna could be manipulated while driving the vehicle. A combination of rough logging roads and heavy roadside vegetation limited the maximum height of the antenna to 4.5 m from the ground. A compass rose attached to the bottom of the mast was keyed to the mast so that when the rose was set to zero, the antenna pointed forward.

A magneysn remote compass mounted in the vehicle permitted rapid determination of the vehicle direction. This compass consisted of a remote sensor and an indicator calibrated in degrees. We installed the sensor in a shock-resistant aluminum box and mounted it on the fiberglass canopy in the rear of the vehicle to minimize unwanted magnetic influences.

We used an error polygon (Heezen and Tester 1967; Springer 1979) program developed in BASIC by Page (1983), to determine the precision of the relocation while in the field. This short program could receive up to five bearings and determine that at least one bearing was inaccurate. The operator had to determine which bearing was to be eliminated. Output from this program included all input data (station number and bearing) plus the Universal Transverse Mercator (U.T.M.) coordinates of the vertices of the error polygon, the U.T.M. coordinates of the centroid, the area of the polygon in hectares (a smaller polygon implying a more precise location), and a plot of the polygon's shape.

The steps in locating a collared grizzly were as follows. The investigator drove to the station closest to where the last bearing was recorded, raised the antenna, locked it into position, and scanned through 360°. If no signal was heard, or if the signal was too weak for a reliable bearing, the investigator partially lowered the antenna and drove toward the next closest station for the last known location, monitoring along the way.

When a signal was received, the operator determined the bearing by the strongest signal method, repeating this process several times to test the precision of the measure, and then entering bearing direction, magnesyn compass reading, and monitoring station number into the computer. The U.T.M. coordinates of the station were extracted from computer memory. After recording three to five positions, we ran the program, taking consecutive bearings and entering them until the size of the error polygon was as small as possible.

Site Investigations

We attempted to identify and evaluate habitat characteristics which are important in determining movements between and use of specific habitat units by conducting site investigations in areas of recent grizzly activity. The U.T.M. coordinates of radio-located bears were transferred daily to an air photo mosaic; locations having an uncertainty area of less than 1 ha were selected for investigation the following day. We did not attempt to visit the site if the bear remained in the same area. We used colour air photographs (1:20,000) to navigate to the centroid of the location polygon, and then searched the area for evidence of recent grizzly activity. When we encountered bear activity, the exact site location, confirmation of grizzly activity, and date of use were required to complete a site investigation form. Where possible, activities were assigned to individual grizzlies. Ground follow-up of visual observations, periodic visitation to areas of traditional grizzly use, and chance encounters with grizzly sign also provided records of activity.

Information collected during site investigations included the ecosystem unit as defined by Banner and others (this volume) and which grizzly activities had occurred at the site (feeding, bedding, tree marking, trail marking, traveling and other). It was not uncommon to have more than one activity per site. We also recorded a number of site characteristics, which were selected on the basis of their suspected biological relevance to bears and which had to be measurable to a desired level of precision. A sample site investigation form is presented in Appendix A.

Seasons of grizzly activity were based on information collected during site investigations. Eight annual grizzly seasons were defined on the basis of plant phenology and the availability of preferred food. Following is a brief description of each season.

Season number	Start	Definition
1	Early April	Emergence to valley floor leaf flush
2	Mid-April	Leaf flush to avalanche chute green up
3	Late May	Avalanche chute green up to berry production
4	Mid-June	Berry production, no salmon
5	Late July	Berries and salmon
6	Late August	Salmon, no berries
7	Mid-October	Post-salmon
8	Early November	Denning

The dates listed above are approximations only because of the between-year variation in season commencement. For example, in 1982, season 4 began on July 1, whereas in 1983 it began on June 16.

Feeding Evaluation

Diet analysis.--In 1982, bear scats were collected as encountered. In 1983 and 1984 only known-bear, known-date scats were collected. Samples were air dried in the field and stored in paper bags until analysis. In the lab, samples were resaturated in water and washed through two screens of mesh sizes 4 mm and 1 mm. Five subsamples were selected randomly for examination under a stereo microscope (2X and 4X). Scat material was identified to species when possible, but grasses and sedges were classified only to family. Percent occurrence by volume was recorded in the following classes (Servheen 1979): 0-1, 1-5, 5-25, 25-50, 50-75, 75-95, 95-100 and averaged for the five subsamples.

Site analysis.--Where we could verify feeding activity, we collected specific site data. We identified food species, listed them in order of volume consumed, and classified them by phenological stage. For fruit-producing shrubs and salmon, we also determined approximate abundance.

In 1984, we collected representative food samples for analyses of crude protein, acid detergent fiber, and energy. At verified feeding sites, three types of samples were collected: remains of what the bear had consumed, a mimic (or imitation) of what the bear had selected, and a mimic collected up to a month later. These analyses will be compared to the analysis of food plants collected once per season at permanent plots. Hypotheses regarding the influence of food quality on seasonal habitat and within site food selection are being tested.

Computer mapping.--Two 1:20,000 map sheets covering the majority of the study area and all of the area mapped by Banner and others (this volume) were digitized for the computer-aided planning assessment and map production (CAPAMP) system developed by the British Columbia Ministry of Environment. CAPAMP will rapidly measure availability of all mapped units and produce interpretive maps that can be used to direct further research or highlight areas of management concern (Archibald and others 1985).

RESULTS

Three seasons of field work have been completed (1982-84). Seasons generally proceeded from early April through mid-October, except when a labor dispute closed the camp from July 29 through August 21, 1982, and when field work terminated on September 9, 1982.

Capture

Twelve grizzlies have been captured in the intensive study area, four of which are known to have died subsequently. One adult male was shot by a hunter, a subadult male was shot as a problem bear, a subadult female is believed to have died of natural causes, and an adult male died as a result of immobilization.

We have observed additional unmarked grizzlies within the intensive study area. The area is being trapped again in the spring of 1985 in an attempt to replace radio collars and to capture all unmarked resident grizzlies.

Radio relocations

We have collected the majority of data in the intensive study area from two resident, adult female grizzlies, numbered 08 and 25. To date we have recorded 362 ground radio relocations for female 08 and 344 relocations for female 25. These radio relocations plus a few visual observations have led to 106 verified ground locations for female 08 and 126 verified ground locations for female 25. We verified grizzly bear activity at approximately 35 percent of ground telemetry locations.

We tested the accuracy of the telemetry system by placing a radio collar at known locations throughout the study area and then plotting their locations using the standard telemetry methodology. Preliminary analysis of these data reveals that caution must be exercised when determining habitat use strictly from unverified ground telemetry data. We have analyzed 12 of 52 tests to date and only in one case was the test collar within the error polygon. The average distance from the centroid of the polygon to the test collar was 150 m.

Site investigations

To date, we have completed 406 site investigations on identified and unidentified grizzlies and have 786 records of grizzly activity.

Diet analysis.--We observed an attempted kill of an ungulate only once, on April 29, 1984 when two sibling male grizzlies chased an adult moose in a cutover. We do not know whether they were successful. We found one bear-scavenged moose carcass in 1982 and collected several grizzly scats containing moose calf hair in early July 1983. We have recorded evidence of 29 foods for Kimsquit grizzly bears, based on scat analyses and investigations of feeding sites (table 1). Diet consists primarily of plant material, including shoots, roots, and berries, but also includes salmon. Six food items appear to form the bulk of the diet (table 2).

Table 1.--Verified grizzly foods--Kimsquit Valley[1]

Latin name	Common name	Parts consumed
Plants		
Angelica genuflexa	White angelica	Roots, stems, and leaves
Athyrium felix-femina	Ladyfern	Pinnae
Carex sitchensis	Sitka sedge	Blades
Cicuta douglasii	Water hemlock	Stems and leaves
Cornus sericea	Red-osier dogwood	Berries
Equisetum spp.	Horsetail	All?
Heracleum sphondylium	Cow-parsnip	All
Lonicera involucrata	Black twinberry	Berries
Lupinus nootkatensis	Nootka lupine	Roots
Lysichiton americanum	Skunk cabbage	Roots (some leaves)
Oplopanax horridus	Devil's club	Leaf stems and berries
Osmohiza chilensis	Mountain sweet-cicely	Roots
Poaceae	Grasses	Blades
Ribes bracteosum	Stink currant	Berries
Rubus idaeus	Red raspberry	Berries
Rubus spectabilis	Salmonberry	Shoots, leaves, and berries
Sambucus racemosa	Red-elderberry	Berries
Scirpus microcarpus	Smallfruited bulrush	Blades
Carex spp.	Sedges	Blades
Streptopus roseus	Rosy twisted Stalk	Berries
Vaccinium spp.	Blue and red huckleberries	Berries
Veratrum viride	Green false hellebore	Stems
Viburnum edule	Highbush cranberry	Berries
Insects		
Cedoptera spp.	Beetle	Larvae
Bombus spp.	Honeybee	Larvae
Fish		
Oncorhynchus gorbuscha	Pink salmon	All
Oncorhynchus keta	Chum salmon	All
Oncorhynchus nerka	Sockeye salmon	All
Mammals		
Alces alces	Moose	Flesh

[1] Plant nomenclature follows Talor and MacBryde (1977) for both common and scientific names.

Table 2.--Most common food items at feeding sites of bear numbers 08 and 25

Food	N	Percent
Scirpus microcarpus	13	7.6
Lysichiton americanum	21	12.4
Oplopanax horridus	24	14.1
Rubus spectabilis	11	6.5
Sambucus racemosa	18	10.6
Salmon (fresh)	25	14.7
Salmon (rotten)	10	5.9
Other	48	28.2
	[1] 170	

[1] At 117 different feeding sites.

For some food species, particularly those that are grazed (for example, sedges, grasses, horsetails, ladyfern, but also Vaccinium spp.), verification of use was often difficult because feeding sign was hard to find. Thus, these species may be underrepresented in the tables. When completed, scat analyses will help correct this bias. Either method alone is inadequate to describe diet reliably.

Habitat unit evaluation for feeding.--We have recorded 112 records of feeding activity for bears 08 and 25, in 25 different seral variations of the ecosystem associations described by Banner and others (this volume). Sixty-four percent (72 of 112) of the records of feeding have been recorded in the Floodplain spruce (Picea sitchensis)-devil's club (Oplopanax horidum) ecosystem association and its seral variations (table 3).

Table 3.--Frequency of feeding in the variations of the floodplain spruce ecosystem association by bear numbers 08 and 25

Symbol[1]	Name Ecosystem variation	Successional stage	Frequency
VI	Orthic vegetation	Young climax-old growth (F-H)	8
VI(1)	Cottonwood-spruce-salmonberry-devil's club	Mature seral-young climax (E-F)	10
VI(2)	Cottonwood-devil's club	Mature seral (E)	7
VI(3)	Cottonwood-alder-salmonberry-devil's club	Mature seral (E)	6
VI(4)	Alder-salmonberry-elderberry	Mature seral (E)	11
VI(5)	Alder-salmonberry	Pole-sapling (D)	15
VI(6)	Alder-grass	Pole-sapling (D)	2
VI(7)	Salmonberry-ladyfern	Shrub-seedling pioneer seral	0
VI(8)	Alder-willow-fireweed-Rhacomitrium-river bar complex	Herb/shrub seeding pioneer (A-C) seral	9
VI(9)	Cottonwood-alder-twinberry	Pole sampling (D)	4
VI(10)	Spruce-cottonwood-thimbleberry	Pole sampling-mature seral (D-E)	0

[1] Explanation of ecosystem variation symbols can be found in Banner and others (this volume).

Apparently, grizzlies select this ecosystem association for feeding partly because of its proximity to salmon.

DISCUSSION

The relatively low conversion rate of radio relocations to site investigations is explained by two factors: ground telemetry in the study area being limited by thick vegetation, rock cliffs, frequent wind and rain, and variable microtopography across the floodplain; and, the rigorous verification criteria used to select sites. Bear activity was actually encountered near relocation sites approximately 50 percent of the time but resulted in only a 35 percent conversion rate because of a high density of black bears in the valley and the great amount of different age bear sign we encountered on the floodplain.

Regardless of the low conversion rates, our telemetry system has proved adequate for our purposes. Repeated testing of the accuracy and precision of the ground telemetry system determined the extent of relocation error. As a result, we increased the search area around a recent telemetry relocation. Better ground telemetry would have reduced the searching time for grizzly use sites, increased the number of site investigations, and prevented potential bias in habitat unit evaluation resulting from non-uniform ground telemetry coverage. Aerial relocation data, ground telemetry testing, and rigorous analysis of movement data (by taking into account the distribution of relocations over time) will help to eliminate this bias.

The telemetry system did fulfill two of the original three criteria. That is, it permitted rapid collection of consecutive bearings and protected the equipment from inclement weather. In addition, this system was excellent for telemetry at night.

The site investigation procedure has proven to be time consuming and labor intensive. Initial discussions with statisticians led us to believe that the data we were collecting could be used to build a quantitative model of habitat selection; however, further discussions and attempts at data analysis have resulted in our abandoning this work. Major problems with the data-set are that it contains a combination of continuous and categorical variables, and that consecutive bear locations are not independent of one another.

The site investigation procedure has proven successful in spite of these shortcomings. It has allowed us to assign grizzly activities (not just locations) to specific habitat units--these data are essential to the habitat unit evaluation procedure. Simple summary statistics can be run on all continuous variables, and frequency summaries and contingency testing of categorical variables can help to identify patterns and allow testing for significant differences between individual bears, activities, and seasons. Such procedures, although not statistically eloquent, do provide information useful for management.

We suggest considering numerous factors when evaluating grizzly habitat units in terms of their value to grizzlies on a seasonal and annual basis. These factors include the following:

1. The area coverage and distribution of the unit (spatial availability).
2. When and how long the unit's features remain attractive to bears and their annual variability (temporal availability).
3. The number, spatial and temporal availability of alternate, equivalent-value habitat units during the period of bear use for a particular unit.
4. The details of bear use of the unit: the timing, extent, life requisite being satisfied, and the number of bears using the unit are required information (relocation biases and the distribution of bear locations over time must be accounted for to provide truly representative information about the nature, timing, and extent of use).
5. The amount of human disturbance (for example, noise or physical presence of people or vehicles) and its influence on bear use of the unit.

The procedure outlined to evaluate the floodplain spruce ecosystem association for feeding will be expanded to include the above factors in future reports. In this way, all habitat units will be ranked in terms of their value to grizzlies in the intensive study area on a seasonal and annual basis.

Once we know the comparative value of habitat units for all activities and all seasons, the CAPAMP system can be used to generate interpretive maps useful to management. For example, this system could be used to display the distribution of seasonally important habitat units for grizzlies.

In conclusion, the system that we are using to evaluate the habitat units mapped by Banner and others (this volume) is still evolving. We plan to field test unit evaluation for a number of other watersheds to determine whether we can extrapolate our results over the coast. We are confident that the process outlined in this paper is the correct strategy for our study area, and that the results of our research will allow us to achieve project objectives.

REFERENCES

Archibald, W. R. Problem analysis: grizzly bears and coastal development with particular reference to intensive forestry. Bull. No. B-26. British Columbia Ministry of Environment Fish and Wildlife Branch; 1983. 24 p.

Archibald, W. R., Sondheim, M.; Hamilton, A. N. Computerized mapping as an aid to grizzly bear habitat definition. In: Proceedings, 64th annual conference of the Western Association of Fish and Wildlife Agencies; 1984 July 17-19; Victoria, B.C; 1985:215-223.

Banner, A. Ecosystem classification and mapping in the coastal western hemlock zone, mid-coast drier transitional subzone (CWHh), Kimsquit River Valley, British Columbia. British Columbia Ministry of Forests, Research Section, Smithers, B.C. (in preparation).

Banner, A., Pojar, J., Trowbridge, R., Hamilton, A.N. Grizzly bear habitat in the Kimsquit river valley, coastal British Columbia: classification, description, and mapping. In: Proceedings, grizzly bear habitat symposium; 1985 April 30-May 2; Missoula, MT. (this volume).

Clement, C. Habitat types of the Kimsquit river estuary. Working Report WR-4. Victoria, B.C: British Columbia Fish and Wildlife Branch; 1984a. 27 p.

Clement, C. Biogeoclimatic units and ecosystem associations of the Kimsquit drainage. Working Report WR-5. Victoria, B.C: British Columbia Fish and Wildlife Branch; 1984b. 93 p.

Glen, L. P.; Miller, L. M. Seasonal movements of an Alaskan Peninsula brown bear population. In: Martinka, C. J.; McArthur, K. L. eds. Bear biology association conference series; Washington, DC; 1980: 307-312.

Hamilton, A. N. Progress report coastal grizzly research project, year 1. Working Report WR-1. Victoria, B.C: British Columbia Fish and Wildlife Branch; 1984. 43 p.

Heezen, K. L., Tester, J. R. Evaluation of radio-tracking by triangulation with special reference to deer movements. Journal of Wildlife Mangement. 31:124-141, 1967.

Krajina, V. J. 1970. Ecology of forest trees in British Columbia. In: Krajina, V. J.; Brooke, R. C., eds. Ecology of Western North America. Vancouver, B.C: University of British Columbia; 1970:1-146.

Nolan, J. W.; Russell, R. H.; Anderka, F. Transmitters for monitoring Aldrich snares set for grizzly bears. Journal of Wildlife Management. 48(3):942-944, 1984.

Page, R. E. A computer program for radio telemetry data in the field. 1983. Unpublished report on file at: British Columbia Ministry of Forests, Research Branch, Victoria, BC.

Russell, R. H., Nolan, J. W.; Woody, N. G.; Anderson, G. H. A study of the grizzly bear in Jasper National Park 1975 to 1978. Edmonton, Alta. Canadian Wildlife Service; 1979. 136 p.

Servheen, C.; Lee, L. Mission Mountains grizzly bear studies-an interim report 1976, 1978. Border Grizzly Project Special Report No. 31. 1979. Unpublished Report on file at: University of Montana, Missoula, MT. 299 p.

Springer, J. T. Bias and sampling error in triangulations. Journal of Wildlife Management. 43(4):926-935, 1979.

Taylor, R. L.; MacBryde, B. Vascular plants of British Columbia: A descriptive resource inventory. Technical Bulletin Number 4. Vancouver, B.C.: The Botanical Garden, University of British Columbia; 1977. 754 p.

Appendix A

FISH & WILDLIFE BRANCH
RESEARCH SECTION

SITE INVESTIGATION FORM

FORM #

SITE CHARACTERISTICS

SITE # (6)

DATE D D M M Y Y (9)

SURVEYORS (15) (17) (18)

X COORD (21)

Y COORD (28)

PLOT SIZE (m) (31)

ELEVATION (m) (35)

SLOPE (39)

ASPECT (42)

HABITAT CHARACTERISTICS

TYPE (45)

POLYGON (51)

STRATA %
TREE (55) B1 (57) B2 (59) C (61) D (63)

COVER VALUE N E S W (65)

TYPE
1 Shrubs
2 Debris
3 Topography
4 Trees
N E S W (73)

TRAFFIC (circle 1 max)
(77)
1 Unrestricted
2 Slight
3 Restricted
4 Very
5 Extreme

SOIL TYPE (78)

MOISTURE (81)

NUTRIENT (84)

HUMUS (85)

SURFACE TEX (87)

SURFACE SUBSTRATE %
LITTER (91) HUMUS (93) DECAY WOOD (95) BEDROCK (97) ROCKS (99) MINERAL SOIL (101) H20 (103)

FLOODING (circle 1 max)
(105)
1 Now
2 1 Month
3 This Year
4 Not Active

ACTIVITY CHARACTERISTICS

ACTIVITY (circle 6 max)
(108 111)
1 Bed
2 Feed
3 Mark Tree
4 Mark Trail
5 Travel
6 Other
SPECIFY
* - Primary Activity

SEASON (circle 1 max)
(112)
1 Leaf Flush
2 Chute Greenup
3 Berry Production
4 Berry to Salmon
5 Berry & Salmon
6 Salmon
7 Post Salmon

WEAT USE (circle 1 max)
(113)
1 Unknown
2 Rain
3 Intermittent Rain
4 Overcast
5 Cloudy
6 Few Clouds
7 CAVU
8 Other
SPECIFY

USE/RELOC DATE
D D M M Y Y
(114)

SIGN AGE (120)

BEAR # (122)

RELOC SHEET # (124)

TELEMETRY RELIABILITY
(circle 1 max)
(127)
1 Positive
2 Probable
3 Possible
4 Doubtful

VERIFICATION
(circle 7 max)
(128 134)
1 Hair
2 Tracks
3 Telem
4 Visual
5 Age
6 Scat
7 Disturbance

BED MEASUREMENTS
LENGTH (135) WIDTH (138)

DEPTH (147) BED TREE (148) D B H (152)

OTHER BEARS #
1 (141) 2 (143) 3 (145)

MARK TRAIL
LENGTH (155)

IMPRESSIONS (157)

STATUS (circle 1 max)
(159)
1 Permanent
2 Occasional

MARK TREE
SPECIES (160) D B H (162) HT MARKED (165) AGE (168)

FOOD SPECIES (order of use)
1 2 3 4 5 (171)

FOOD SAMPLE LABELS
SITE # FOOD SITE # FOOD SITE # FOOD SITE # FOOD SITE # FOOD
(176) (184)

OTHER WILDLIFE
(circle 5 max)
(196 200)
1 Moose
2 Deer
3 Black Bear
4 Goat
5 Wolf
6 Other
SPECIFY

OTHER WILDLIFE USE
(circle 5 max)
(210 205)
1 Bed
2 Browse
3 Graze
4 Dig
5 Tracks
6 Scat Pellets
7 Other
SPECIFY

CONTINUE ON REVERSE

SITE INVESTIGATION FORM CONTINUED

DISTANCE MEASURES

TO OPENING (m) (206)

HABITAT TYPE (208)

TO COVER (m) (214)

TYPE OF COVER (217)

COVER VALUE N E S W (223)

COVER TYPE N E S W (231)

TO HUMAN ACT (m) (235)

ACTIVITY TYPE
(circle 2 max)
(239 240)
1 Road
2 Clear Cut
3 Air Strip
4 Camp
5 Dry Land Sort
6 Spur Road
7 Other
SPECIFY

CURRENT USE
(circle 2 max)
(241 242)
0 None
1 Telemetry Vehicle
2 Cat Taker
3 Falling/Bucking
4 Yarding/Loading
5 Hauling
6 Sorting
7 Road Construction
8 Full Operation
9 Other
SPECIFY

WITHIN ZONE ONLY
AVG COVER VALUE (243)

COVER TYPE (245)

NOISE LEVEL (246)

COMMENTS

TO WATER (m) (249)

SALMON AVAILABILITY
(circle 1 max)
(252)
1 None
2 Low
3 Medium
4 High

SALMON ABUNDANCE
(circle 1 max)
(253)
1 None
2 Low
3 Medium
4 High

TO PREDOMINATE

ASSOCIATED HABITAT (m) (254)

HABITAT TYPE (257)

COVER VALUE N E S W (263)

DESCRIPTION

PHOTO # (271)

FILM # (277)

SCAT # (278)

SITE DIAGRAM

N

COMMENTS

MAPPING GRIZZLY BEAR HABITAT IN GLACIER NATIONAL PARK USING A STRATIFIED LANDSAT CLASSIFICATION: A PILOT STUDY

Bart R. Butterfield and Carl H. Key

ABSTRACT: An existing Landsat classification, one of 20 data bases comprising a regional geographic information system, was used to create a first-generation map of grizzly bear habitat in the Two Medicine drainage of Glacier National Park, MT, and to assess the potential for using Landsat to produce a park-wide habitat map. A total of 189 Landsat classes, stratified by elevation and aspect, were grouped into 18 habitat classes significant to grizzly bears. Six forested habitat classes represented habitat types or combinations of habitat types that appeared to provide similar resources to grizzly bears. Other habitat classes generally corresponded with the widely accepted grizzly bear habitat component system. The stratified Landsat classification demonstrated a moderate capability to resolve the array of grizzly bear habitat classes. An improved classification may be achieved by restructuring the existing Landsat classification and incorporating relevant ancillary themes, such as time-since-burn and snow chute locations.

INTRODUCTION

Landsat analysis is widely recognized as a potentially powerful tool for mapping large expanses of wildlife habitat (Loffler and Margules 1980; Lyon 1983; Thompson and others 1980). Landsat has been applied to grizzly bear habitat mapping (Craighead and others 1982), but because it is often criticized for its low resolution and inaccuracy, it has been largely ignored for this use. Inadequacies have stemmed partially from sole reliance on the discriminating capabilities of Landsat data. Improved cover type classifications may be achieved through topographic stratification (Hoffer and others 1979; Justice and others 1981; Rhode and others 1979), but stratified Landsat classifications cannot, by themselves, sufficiently map grizzly bear habitat because habitat quality also depends on characteristics such as distance to water, time since last burn, and presence of snow chutes (Mealey and others 1977; Servheen 1983; Zager and others 1983). Those attributes cannot be detected by Landsat's spectral data alone and cannot be accurately represented by topographic data planes. To map grizzly bear habitat, relevant ancillary data themes must be incorporated into the habitat classification process along with the Landsat-derived cover type theme in the context of geographic information systems (Marble and Peuquet 1983; Wherry and others 1985).

The ultimate goal of this ongoing project is to develop a map of grizzly bear habitat in Glacier National Park and, possibly, seasonal maps. This paper presents the results of the first step toward that goal: a first-generation habitat map, derived from a stratified Landsat classification, in the Two Medicine drainage of Glacier National Park. We evaluate the map and recommend ways of restructuring the Landsat classification and improving the information content by incorporating ancillary data themes.

METHODS

The grizzly bear habitat classification developed in two stages (fig. 1). The first stage was a general, stratified Landsat classification. The second stage was application of the stratified Landsat classification to form the grizzly bear habitat classification.

Stratified Landsat Classification

The stratified Landsat classification used to map grizzly bear habitat existed as one of multiple layers in a geographic information system created jointly by Flathead National Forest and Glacier National Park (Wherry and others 1985). It was derived from MSS Landsat 3 data utilizing VICAR/IBIS, a batch image-proccssing software package (Hart and Wherry 1984). Processing was conducted through the Digital Image Analysis Laboratory, Washington State University.

We classified the four bands of spectral data into 99 spectral classes using a guided clustering approach (fig. 1). We generated an elevation plane from DMA digital terrain tapes with interpolation to 40-ft intervals and created an aspect plane with increments of 5 degrees from the elevation plane. Stratification of the elevation and aspect planes permitted us to generate output planes with increments deemed

Paper prepared for publication in the Proceedings of the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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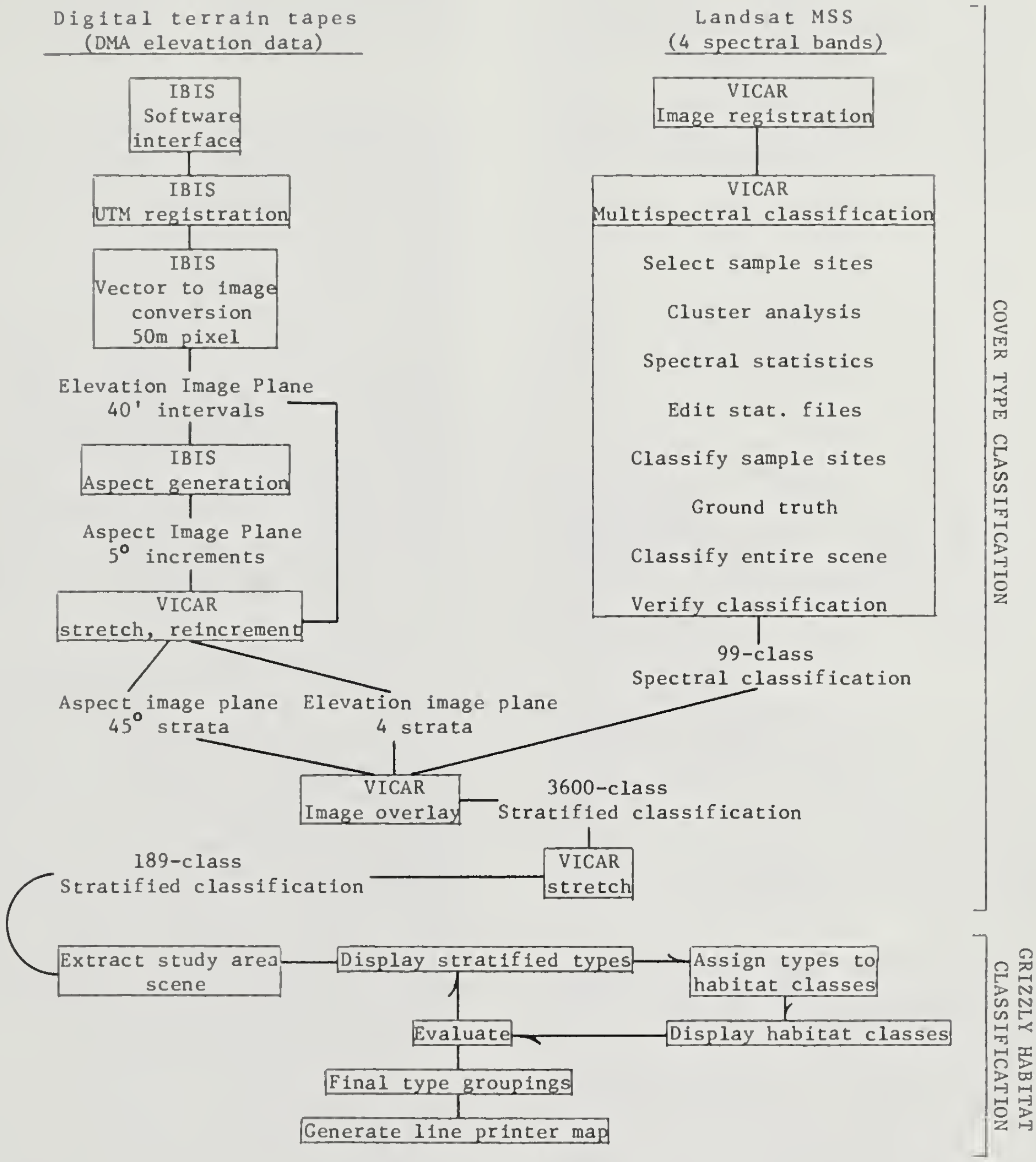

Figure 1.--A general flow chart of classification procedures.

suitable for mapping plant unions. Four strata were created for elevation and nine for aspect. All data planes were geometrically corrected and registered to the U.T.M. coordinate system.

The stratified Landsat classification was produced from the 99-type spectral classification, the four-strata elevation model, and the nine-strata aspect model. The initial classification contained 3,600 stratified classes and was reduced to 189 information types. A hierarchical legend of the stratified classification grouped similar Landsat classes according to discriminating characteristics and ordered them by relative discriminating power as follows:

WATER

- Water type

SNOW

- Snow type

LAND RESOURCES

- Agricultural
  - Agricultural type (irrigated, nonirrigated, pasture, plowed)
    - Agricultural class within type
- Barren lands
  - Moisture condition (dry, mesic, moist)
    - Elevation (lowland, subalpine to alpine)
      - Type of substrate
- Natural vegetation
  - Major life form (coniferous forest, shrub, herbaceous)
    - Moisture condition (dry, mesic, moist)
      - Elevation (lowland, midelevation, subalpine, alpine)
        - Canopy closure or density (low, medium, high)
          - Species composition or character of exposed substrate
            - Plant vigor (especially, beetle-killed lodgepole pine)

Note that species composition is one of the lowest levels and is comparably unreliable for differentiating among types.

Grizzly Bear Habitat Classification

We derived grizzly bear habitat classes from the stratified Landsat classification. The term "habitat class" is used to avoid confusion over the popular term "grizzly bear habitat component." We do not imply that we used a fundamentally different classification. In fact, as will be pointed out later in this paper, many of our habitat classes correspond with established grizzly bear habitat components.

The process required interactive use of an image processor, the IIS System 511, and a Conrax RGB monitor. An image of the study area, a 512- x 512-pixel window (655 km^2), was displayed on the monitor. All Landsat classes within the image were sequentially displayed in color and the distribution of each noted on 1:30,000 scale, color infrared aerial photographs. A lengthy iterative process to group and regroup Landsat classes followed. Each group was assigned a pixel color and represented our concept of available grizzly bear habitat classes in the study area. The process ended when no further improvement in the habitat classification could be made with available information. We recorded final stratified Landsat class groupings and ran a batch job with VICAR/IBIS, creating a line printer map at 1:24,000 scale. The map encompassed the entire study area and represented the distribution of each habitat class with pixel symbols.

The line printer map was overlaid by a photomechanical transfer on transparent, copy-proof film of U.S. Geological Survey 7.5-minute topographic maps, which facilitated location in the field. After becoming familiar with vegetation in the study area, we found that some pixel symbols represented the same habitat class, so we combined those symbols to correspond better with actual habitat classes. We then outlined habitat classes on the overlays with a grease pencil as ground-truthing proceeded. These field overlays were traced onto frosted mylar. We overlaid negatives of this map and clean topographic maps to produce the final map, which is available from Glacier National Park, Research Office, West Glacier, MT, or Cooperative Park Studies Unit, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Ground-truthing continued throughout the summer of 1984, concurrent with vegetation sampling. The objective of the sampling was to describe the representative vegetation and account for the full range of variation in each habitat class. Temporary, 375-m^2 plots were subjectively placed in representative stands. Plot allocation was proportional to the approximate availability of each habitat class and plot distribution covered a wide range of environmental conditions within each class. At each plot, pertinent map and physiographic data were recorded: line printer map symbol, sequential plot number, date, U.T.M. coordinates, habitat class, position on slope (ridgetop, upper slope, midslope, lower slope,

bench, or drainage bottom), ground configuration (flat, convex, concave, or undulating), elevation, slope, aspect, percent canopy closure, forest habitat type (if site was timbered) (Pfister and others 1977), and photograph identification number. A complete vascular plant species list was made, and percent cover of each species and rock, mineral soil, litter, deadfall, and nonvascular plants was visually estimated (Pfister and others 1977). Mean height of each species was also estimated.

Data were summarized using the Statistical Analysis System software package (SAS Institute Inc. 1982) at the University of Idaho. Constancy, mean percent cover, and mean height of each species was determined for each habitat class.

RESULTS

Twenty-two pixel types were derived from the stratified Landsat classification. Each was characterized by a major life form and canopy coverage. Some of these were regrouped during the field season, resulting in 18 grizzly bear habitat classes (table 1). Complete descriptions and technical data are available in Baldwin and others (1985). Seventeen of the 22 original pixel types strongly corresponded with specific habitat classes (table 2). The lack of correspondence in the remaining habitat classes can be attributed to the inherent insignificance of species composition in spectral classification or the classification of habitat classes representing transitional sites.

Six forested habitat classes represented habitat types or combinations of habitat types that appeared to provide seasonally distinct resources to grizzly bears (table 3). The most ubiquitous of the forested classes, the lower subalpine-open conifer, occurred on relatively warm, dry aspects and had the greatest plant species diversity of all habitat classes. The lower subalpine-closed conifer habitat class occupied most lower, north-facing slopes. The understory was poorly developed or consisted of dense stands of almost pure menziesia (*Menziesia ferruginea*). The upper subalpine-conifer habitat class formed the forested portion of cirque basins. Big huckleberry (*Vaccinium membranaceum* x *V. globulare*) dominated the shrub layer. The timberline habitat class was relatively dry and consisted of a very open canopy of stunted and deformed conifers. Extensive stands of the lodgepole pine habitat class resulted from the 1910 Dry Fork Fire. The understory was poorly developed, suppressed by a dense canopy. The spruce floodplain habitat class occupied floodplains with seasonally high water tables.

Nonforested habitat classes generally corresponded with established grizzly bear habitat components (Aune and others 1984; Servheen 1983; Zager and others 1983) (table 4).

DISCUSSION

Two problems were encountered that may have influenced the computer-generated habitat classification. First, an error in the aspect plane prevented discrimination between southerly and flat aspects and was not resolved before the mapping process. Second, the Landsat classification had only limited verification on the east side of the park, which differs botanically from the west side, and we were not personally familiar with the vegetation in the study area before the computer grouping process. Therefore, we found it necessary to form computer-generated habitat classes based on our knowledge of the Landsat classes on the west side of the park and our concept of grizzly bear habitat in the study area, as obtained from literature and aerial photos.

As a result, a one-to-one correspondence of original, Landsat-derived habitat class with final, regrouped habitat class was not obtained, in most cases. Each pixel symbol generally represented more than one habitat class, and each habitat class was often represented by more than one pixel symbol. We found, however, that habitat class boundaries, as indicated on the line printer map, were real. Ground-truthing simply involved identifying the actual habitat classes separated by the boundaries. With experience, we were able to identify habitat classes based on pixel symbol, topographic or physiographic position, and association with other pixel symbols and surrounding grizzly bear habitat classes.

The two problems noted above have now been resolved, and we believe that a more accurate, second-generation map can be made simply by restructuring the existing stratified Landsat classification. Requiring about 8 hours, the process would utilize the IIS System 511 interactive image processor and incorporate site information acquired since generating the first map.

Grizzly bears spend a great deal of time in timber (Aune and others 1984; Martinka 1972); however, current grizzly bear habitat mapping efforts fail to identify ecologically meaningful forest communities. The only forested grizzly bear habitat components are open and closed timber (Aune and others 1984; Servheen 1983; Zager and others 1983). Mealey and others (1977) evaluated the potential food value of forested habitat types for grizzly bears and concluded that, besides providing security cover, some habitat types had high food values. Our classification of forested areas generally corresponds to forested habitat types or combinations of habitat types that appear to provide similar resources (table 3). The lower subalpine-closed conifer habitat class included habitat types with low food values (Mealey and others 1977) and those used little by grizzly bears (Aune and others 1984). High food values were reported for habitat types associated with the lower subalpine-open conifer and upper

Table 1.--Grizzly bear habitat class characteristics

	Habitat class	Dominant species	Associated species	Topography	
1	Lower subalpine-open conifer	Subalpine fir	Utah honeysuckle	Elev.	5,000-6,680 feet
		Big huckleberry	Western meadowrue	Slope	0-30 degrees
		Beargrass	Cascade mountain-ash	Aspect	All
			Lodgepole pine	Position	All
2	Lower subalpine-closed conifer	Menziesia	Big huckleberry	Elev.	5,100-5,860
		Subalpine fir	Beadlily	Slope	0-27
		Spruce	Foamflower	Aspect	N (S, W)
		Beargrass	Cascade mountain-ash	Position	Lower, mid, bottoms
3	Lodgepole pine	Lodgepole pine	Grass	Elev.	4,900-5,650
		Big huckleberry	Spruce	Slope	0-30
		Beargrass	Heartleaf arnica	Aspect	S, W (NE)
		Shiny-leaf spirea	Douglas-fir	Position	Mid, benches, bottoms
4	Upper subalpine-conifer	Subalpine fir	Mountain arnica	Elev.	5,500-6,750
		Big huckleberry	Whitebark pine	Slope	6-28
		Beargrass	Menziesia	Aspect	All
		Smooth woodrush	Spruce	Position	Upper, mid, lower
5	Spruce floodplain	Spruce	Willow	Elev.	4,900-5,480
		Western meadowrue	Subalpine fir	Slope	0
		Grass	Arrowleaf groundsel	Aspect	-
		Common horsetail	One-sided wintergreen	Position	Bottom
6	Timberline	Subalpine fir	Smooth woodrush	Elev.	5,900-7,100
		Sedge	Grass	Slope	5-40
		Whitebark pine	Big huckleberry	Aspect	All
		Beargrass	Western meadowrue	Position	Mid, upper
7	Krummholz	Subalpine fir	Cinquefoil	Elev.	6,700-7,800
		Spruce	Yellow hedysarum	Slope	11-35
		Whitebark pine	Grass	Aspect	All
			Explorer's gentian	Position	Mid, upper
8	Cirque basin complex	Sedge	Indian paintbrush	Elev.	6,100-6,750
		Glacier lily	Subalpine fir	Slope	4-24
		False hellebore	Grass	Aspect	All
		Arrowleaf groundsel	Aster	Position	Mid, lower, bottom
9	River floodplain	Black cottonwood	Grass	Elev.	4,950-5,900
		Fireweed	Yarrow	Slope	0-5
		Swamp gooseberry	Willow	Aspect	-
		Whiteleaf phacelia	Hooker's thistle	Position	Bottom
10	Aspen	Aspen	Grass	Elev.	4,900-5,580
		Western meadowrue	Western sweet-root	Slope	0-15
		Black cottonwood	Fireweed	Aspect	S, E
		Common snowberry	Showy aster	Position	Mid, lower, benches
11	Bunchgrass slope	Grass	Serviceberry	Elev.	5,250-6,250
		Pussytoes	Northern bedstraw	Slope	10-35
		Silky lupine	Yarrow	Aspect	S, E (N, NW)
		Kinnikinnick	Sedge	Position	Upper, mid, lower
12	Mesic shrub	Beargrass	Fireweed	Elev.	5,250-6,400
		Cascade mountain-ash	Western meadowrue	Slope	0-10
		Subalpine fir	Shinyleaf spirea	Aspect	All
		Big huckleberry	Grass	Position	Mid, lower

(con.)

Table 1. (Con.)

	Habitat class	Dominant species	Associated species	Topography	
13	Dry shrub/grass	Kinnikinnick	Aspen	Elev.	5,500-6,100
		Grass	Silky lupine	Slope	16-25
		Buffaloberry	Beargrass	Aspect	S, E
			Common juniper	Position	Mid, lower
14	Hydric shrub	Sitka alder	Grass	Elev.	5,250-5,800
		False hellebore	Sweet-scented bedstraw	Slope	5-26
		Stream violet	Stinging nettle	Aspect	All
		Western meadowrue	Arrowleaf groundsel	Position	Lower
15	Meadow	Grass	Sedge	Elev.	5,165-5,925
		Northern bedstraw	Pussytoes	Slope	0-10
		Roundleaf alumroot	Common horsetail	Aspect	-, (W)
		Strawberry	Yarrow	Position	Bench, bottom
16	Marsh	Willow	Grass	Elev.	4,900-5,200
		Sedge	Swamp gooseberry	Slope	0
		Bearberry	Common horsetail	Aspect	-
		Rush	Aster	Position	Bottom
17	Talus/rock/scree	Grass	Yarrow	Elev.	5,700-9,000
		Matted saxifrage	Lanceleaved stonecrop	Slope	13-90
		Cinquefoil	Elliptic-leaved penstemon	Aspect	All
				Position	Mid, upper, ridgetop
18	Vegetated talus/ rock/scree	Grass	Sedge	Elev.	5,520-8,000
		Cinquefoil	Lanceleaved stonecrop	Slope	5-35
		Yarrow	Yellow hedysarum	Aspect	All
		Northern bedstraw	Yellow buckwheat	Position	Mid, upper, ridgetop

Table 2.--Percentage of 22 original pixel symbols among 18 grizzly bear habitat classes[1]

Habitat class	Pixel Symbol																					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1			20	20	11	80	57		75													
2	67			33																		
3	22			27			7															
4		100	20		22		14	100					25									
5			20		44		7				11	7		20								
6							7					7										
7										25		21										
8			20	13			7		13													
9											11	14				13						
10																31						
11					11									80	9	6	17		50			
12					11	20			13			14			82	6	50		17			
13												14					17		17			
14															9	25	17			100		
15				7							11	7				6			17			
16	11		20									7				13						
17											11							100			100	100
18										75	56	7	75									

[1]Pixel symbols are arbitrary symbols used on Landsat-derived line printer map. Habitat class numbers refer to table 1.

Table 3.--Distribution of forested habitat types among forested grizzly bear habitat classes, as number of plots sampled

Forested habitat class	Forested habitat type[1]											
	ABLA/ XETE/ VAGL	ABLA/ CLUN/ XETE	ABLA/ CLUN/ CLUN	ABLA/ CLUN/ MEFE	ABLA/ MEFE	ABLA/ CACA/ CACA	ABLA/ LUHI/ VASC	ABLA/ LUHI/ MEFE	Picea/ EQAR	ABLA/ GATR	PIAL- ABLA	LALY- ABLA
Lower subalpine-open conifer	10	3	2	1	4	1		1				
Lower subalpine-closed conifer		1	2	1	6							
Lodgepole pine	5	1	1									
Upper subalpine-conifer							5	3			1	
Spruce floodplain			1						2	2		
Timberline											8	1

[1]Pfister and others (1977).

Table 4.--Correspondence of habitat classes with established grizzly bear habitat components

	Habitat class	Grizzly bear habitat component[1]
1	Lower subalpine-open conifer	Closed timber, open timber, timbered shrubfield, timber
2	Lower subalpine-closed conifer	Closed timber, open timber, timber
3	Lodgepole pine	Closed timber, open timber, timber
4	Upper subalpine-conifer	Closed timber, open timber, timbered shrubfield, timber
5	Spruce floodplain	Closed timber, open timber, timbered shrubfield, timber
6	Timberline	Closed timber, open timber, timber
7	Krummholz	None
8	Cirque basin complex	Timber/meadow mixture
9	River floodplain	Riparian zone/complex, populus
10	Aspen	Populus
11	Bunchgrass slope	Mountain grassland, sidehill park
12	Mesic shrub	Shrubfield, snowchute, burns
13	Dry shrub/grass	Shrubfield
14	Hydric shrub	Shrubfield, snowchute
15	Meadow	Meadow
16	Marsh	Marsh, riparian shrub
17	Talus/rock/scree	Rock/talus/rubble/scree, slabrock alpine, slabrock--mid to low, ridgetop
18	Vegetated talus/rock/scree	Rock/talus/rubble/scree, slabrock alpine, slabrock--mid to low, ridgetop

[1]Aune and others (1984); Servheen (1983); Zager and others (1983).

subalpine-conifer habitat classes (Mealey and others 1977). Grizzly bear use of habitat types associated with these habitat classes and the timberline and spruce floodplain classes has been reported to be at least seasonally high (Aune and others 1984).

Our nonforested habitat classes generally correspond with established grizzly bear habitat components; however, several of our habitat classes need to be further refined or broken down into vegetation types within physiographic units, similar to the efforts of Mace (1984). For example, hydric shrub, mesic shrub, and dry shrub/grass habitat classes included snow chutes, snowslide surfaces, burns, and other shrubfields. Using stratified Landsat data alone, these types are not readily separable, but given the broad range of information types within the stratified Landsat classification (189 types) and available ancillary data, we believe that sufficient modifications can be made without reclassifying the raw Landsat data.

Snow chutes occur on all aspects, transect several elevation strata, and contain many distinct plant unions. Snow chutes could be mapped, however, by digitizing locations from quadrangle maps or by modeling their positions with slope and hydrologic data. Once the snow chute data base is developed, it could be digitally superimposed on the stratified Landsat classification to specifically identify vegetation types within snow chute reaches.

Like snow chutes, recent burns appear as other shrub-dominated sites within the Landsat classification. More precise mapping of burn-associated vegetation could be achieved if a time-since-last-burn or fire mosaic data base was developed and incorporated into the habitat mapping process. That base does not exist for the Two Medicine study area, but a suitable one has been developed for the North Fork of the Flathead River drainage within Glacier National Park (Key 1983).

Because of moderate spatial resolution, Landsat 3 data do not distinguish small areas, especially meadows and marshes surrounded by forests. Instead, these sites have to be mapped from aerial photos and their locations can then be digitally incorporated into stratified Landsat classifications with other ancillary themes.

Ancillary data, including slope and elevation, could also be used to help separate rock outcrops or cliffy areas from talus slopes that potentially harbor insects used by grizzly bears (Chapman and others 1953; Servheen 1983). It is well documented that grizzly bear feeding habits respond to the phenology of high-elevation plant foods brought about by melting snow cover (Martinka 1972; Servheen 1983). Elevation, stratified by criteria specifically relevant to grizzly bear habitat use, would be an important discriminating variable for mapping habitat on a seasonal basis. Ongoing research on grizzly bear feeding habits in Glacier National Park may provide the necessary criteria (Kendall 1985).

Distance from water is another ancillary theme that would permit more precise mapping of vegetation types associated with riparian zones. Distance-from-water data bases exist for the Flathead/Glacier geographic information system and identify corridors, classified by stream order and water type (for example, lake, intermittent stream, perennial stream) at 150-m intervals from all points occupied by surface water to a distance of 1.3 km (Key and others in preparation).

It is our opinion, based on evaluation of the first-generation map, that a stratified Landsat classification definitely can help resolve the array of grizzly bear habitat classes; however, to achieve truly representative habitat maps, future mapping attempts should incorporate relevant ancillary themes. Once ancillary data bases are compiled in digital formats, and the criteria for applying those data to grizzly bear habitat classification become known, the process of incorporating those informational themes in the mapping exercise is almost trivial.

In the future, the need will arise to develop general, stratified classifications which maximize information content over the full range of surface types (Key in preparation). It will no longer be efficient or cost effective to develop cover type classifications for every specific application. Users with special objectives, such as grizzly bear habitat mapping, will apply their expertise to combine stratified Landsat classes into habitat classes that satisfy their unique needs. Landsat supplies one information source toward developing such classifications, as do topographic, precipitation, human activity, and other ancillary themes.

REFERENCES

Aune, Keith; Stivers, Tom; Madel, Mike. Rocky Mountain Front grizzly bear monitoring and investigations. Helena, MT: Montana Department of Fish, Wildlife, and Parks; 1984. Unpublished report.

Baldwin, Sara B.; Butterfield, Bart R.; Wright, R. Gerald; Machlis, Gary E. Habitat and visitor mapping in the Two Medicine area of Glacier National Park: combining information gathering techniques. Final Report, Subagreement #6 to Cooperative Agreement 9000-3-0002. Moscow, ID: University of Idaho, Cooperative Park Studies Unit; 1985. 110 p.

Chapman, J. A.; Romer, J. L.; Stark, J. Ladybird beetles and army cutworm adults as food for grizzly bears in Montana. Ecology. 36: 156-158; 1953.

Craighead, J. J.; Sumner, J.; Scaggs, G. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Wildlife-Wildlands Institute Monograph 1. Missoula, MT: University of Montana; 1982. 279 p.

Hart, Judy A.; Wherry, D. B. VICAR/IBIS user reference manual. Pullman, WA: Graphics and Image Analysis Group, Computing Service Center, Washington State University; 1984. 3 vol.

Hoffer, R. M.; Fleming, M. D.; Bartolucci, L. A.; Davis, S. M.; Nelson, R. F. Digital processing of Landsat MSS and topographic data to improve capabilities for computerized mapping of forest cover types. LARS Technical Report 011579. West Lafayette, IN: Purdue University; 1979. 159 p.

Justice, C. O.; Wharton, S. W.; Holben, B. N. Application of digital terrain data to quantify and reduce the topographic effect on Landsat data. Int. J. Remote Sensing. 2(3): 213-230; 1981.

Kendall, K. Personal communication. West Glacier, MT: U.S. Department of the Interior, National Park Service, Glacier National Park, Research Division; 1985.

Key, Carl H. Development of a fire information map and data base for Glacier National Park. Technical Supplement 22-C-2-INT-22. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory; 1983. 55 p.

Key, Carl H. Landsat classifications for multiple applications. West Glacier, MT: U.S. Department of Interior, National Park Service, Glacier National Park, Research Division; [in preparation].

Loffler, E.; Margules, C. Wombats detected from space. Remote Sensing of Environ. 9: 47-56; 1980.

Lyon, John G. Landsat-derived land-cover classifications for locating potential kestrel nesting habitat. Photogr. Eng. Remote Sensing. 49: 2,245-250; 1983.

Mace, Richard David. Identification and evaluation of grizzly bear habitat in the Bob Marshall Wilderness Area, Montana. Missoula, MT: University of Montana; 1984. 176 p. M.S. thesis.

Marble, Duane F.; Peuquet, D. J. Geographic information systems and remote sensing. In: Colwell, R. N., ed. in chief. Manual of remote sensing. Falls Church, VA: Amer. Soc. of Photogr.; 1983: 923-958.

Martinka, C. J. Habitat relations of grizzly bears in Glacier National Park, Montana. West Glacier, MT: U.S. Department of the Interior, National Park Service, Glacier National Park; 1972. Unpublished report.

Mealey, Stephen P.; Jonkel, Charles J.; Demarchi, Ray. Habitat criteria for grizzly bear management. In: Proceedings, 13th International Congress of Game Biologists; 1977 March 11-15; Atlanta, GA. Washington, DC: Wildlife Society, Wildlife Management Institute; 1977: 276-289.

Pfister, Robert D.; Kovalchik, Bernard L.; Arno, Stephen F.; Presby, Richard C. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Rhode, Wayne G.; Herts, E.; Miller, W. A. Integration of digital Landsat and terrain data for mapping wildland resources. In: Proceedings, remote sensing for natural resources; [date of conference unknown]; Moscow, ID. Moscow, ID: University of Idaho; 1979. 393 p.

SAS Institute Inc. SAS user's guide. Cary, NC: SAS Institute Inc.; 1982. 2 vol.

Servheen, Christopher. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. J. Wildl. Manage. 47(4): 1026-1035; 1983.

Thompson, Donald C.; Klassen, Gary H.; Cihlar, Josef. Caribou habitat mapping in the southern District of Keewatin, N.W.T.: an application of digital Landsat data. J. Appl. Ecol. 17: 125-138; 1980.

Wherry, D. B.; Hart, Judy A.; Key, Carl H.; Bain, Stan A. An operational interagency GIS: the Glacier National Park/Flathead National Forest project. In: PECORA 10, Proceedings of the Symposium; 1985 August 20-22; Fort Collins, CO. [Publisher unknown]; [in press].

Zager, Peter; Jonkel, Charles; Habeck, James. Logging and wildfire influence on grizzly bear habitat in northwestern Montana. Int. Conf. Bear Res. and Manage. 5: 124-132; 1983.

AN ECOLOGICAL TAXONOMY FOR EVALUATING GRIZZLY BEAR HABITAT IN THE WHITEFISH RANGE OF MONTANA

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ABSTRACT: An ecological classification of forest habitat is presented and a method of grizzly bear habitat assessment discussed. Land area is classified by habitat type, successional stage, and community type. Community types are defined and described. The framework of a grizzly bear habitat use model based on community type distribution and food habits data is offered. Model refinement is possible as phenological, disturbance, and local bear information become available.

INTRODUCTION

Classification and evaluation of grizzly bear (Ursus arctos) habitat have progressed from simpler descriptive terms (Zager and others 1980; USDA Forest Service 1979; Madel and Christensen 1982) to a more ecologically based analysis (Craighead and others 1982). The development of a grizzly bear habitat use model based on a hierarchy of ecological land classifications and a promising interpretation of the forest mosaic as grizzly bear habitat are the focus of this paper. The benefits of such an ecological approach are several: (1) each part of the analysis dovetails with other levels, (2) interpretation is unified and standardized, (3) refinements are possible as more information is obtained, and (4) completed vegetation maps can be used for interpreting vegetation in adjacent areas using LANDSAT imagery and Geophysical Information System (GIS) techniques.

BACKGROUND

There are essentially two approaches to wildlife habitat classification. The first and most widely used approach has been to characterize wildlife habitat according to broadly defined vegetative classes. For this type of classification, intensive sampling is not required. A major drawback is that the classes are usually broad, and the vegetative variability is not described. Consequently, predictability of habitat suitability, plant species occurrence, and structure is low.

The second and more recent approach to wildlife habitat analysis is based on quantitative analysis of vegetation. This classification requires vegetation sampling, and classes are developed from these data. Derived statistics describe the variability of certain indicator species, and this variability can then be standardized. Although this form of classification requires more effort to develop, its high degree of predictability provides a much more useful classification.

Classification of potential or climax plant communities as defined by Daubenmire (1968) is fairly common throughout the western United States. These "associations" are the basis for the habitat type stratification (Pfister and others 1977; Mueggler and Stewart 1980; Cooper and others 1985). This system has been valuable to land managers for stratifying land potential, categorizing productivity, correlating environmental characteristics with vegetation, and formulating general management regimes; however, most existing vegetation in the Northern Rocky Mountains is in a seral state and the association information is not very useful for describing wildlife habitat suitability.

Existing seral vegetation can, however, be classified into community types and correlated with the type and time since disturbance within the habitat type framework. This approach has proved valuable for multiresource interpretations. Various approaches have been described by Hurschle and Hironaka (1980), Hann (1982), Steele (1984), and Arno and others (1985).

Once successional pathways are understood, a model can be developed for each habitat type. Model predictions are based on existing vegetation data, treatment type, and treatment intensity. The model predicts the resulting vegetation composition over time for each treatment. Alternative vegetation treatments, such as wildfire, broadcast burn, or clearcut/broadcast burn, can be evaluated for short- and long-term desirability for a given wildlife species.

This study is based on the assumption that grizzly bears make discrete choices of the plant food items consumed and, therefore, that availability and abundance of food items are key factors in

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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habitat selection by the bear. In addition, habitat attributes offered by the forest mosaic influence this selection. The driving hypothesis of this study is that ecologically defined and mapped community types can be used to accurately predict intraseasonal and interseasonal grizzly bear movement within the forest mosaic.

STUDY AREA

The study area comprises the southern end of the Whitefish Range (lat. 48°30' N., long. 114°15' W.) approximately 8 mi (12.8 km) north of Columbia Falls, MT. Elevation ranges from river benchland at 3,200 ft (973 m) to a few upper subalpine peaks at 7,000 ft (2 133 m). Nine forest habitat types and various phases (Pfister and others 1977) in the subalpine-fir climax series occur over the area. Grassland habitat types (Mueggler and Stewart 1980) occur along high ridges with a southern exposure. Various disclimaxes associated with avalanche chutes and wildfires occur throughout the study area. In addition, much of the study area has been affected by humans. Extensive road construction in all major drainages and subdrainages preceded commercial logging operations, which began in the 1950's. Climate is classified as Pacific Maritime. Big Mountain in the westcentral portion of the study area receives up to 100 inches (254 cm) of precipitation per year, mostly as snow. The study area is approximately 45 mi^2 (155 km^2).

METHODS

The area was initially stratified by mapping habitat types (Pfister and others 1977; Mueggler and Stewart 1980) and successional stages for forest stands (modified from Arno and others 1985) on 1:16,000 color aerial photographs. Seven successional stages were used to stratify forest variation: (1) grass-forb, (2) shrub-seedling, (3) sapling, (4) pole, (5) young, (6) mature, and (7) old growth. Forest stands were delineated by any distinct change in cover type and represent areas of relatively homogeneous cover or density. Information from the Flathead National Forest timber stand data base was used to generate the preliminary habitat type by seral stage units, which were mapped on orthophotos. Information selected from this data base included habitat type, tree density, height, and age of stand. For photo interpretation work, density was interpreted by canopy cover values. Canopy cover values were modified from Arno and others (1985). Using this method, 100 percent of the study area was initially mapped to habitat type and successional stage.

A rapid reconnaissance method was employed to gather data. This approach emphasized "characterizing" stands (Arno and others 1985; O'Brien and Van Hooser 1983) based on dominant species' cover values. Our approach was to estimate total canopy cover for each major plant species and all bear food plant species present in the stand. The entire stand was considered a "macro" plot. We walked through this stand once to note species and relative abundance. If a stand was particularly large or complex, we did a second walk-through. Occasionally a stand consisted of a mosaic of small, diverse communities. In such stands, we examined each distinct community separately while the mosaic was mapped as a single unit. Estimates of total cover for each species were made at the conclusion of the second pass. Coverage classes were based on a 10-point system:

Code	Percent canopy cover
0	0-1
1	2-4
2	5-10
3	11-20
4	21-30
5	31-40
6	41-50
7	51-60
8	61-70
9	71-80
10	81-100

Additional variables measured in each stand are as follows:

For trees:

- Height of dominant trees
- Total cover all trees
- Density (number of trees within a circle with radius of 25 ft)
- Canopy cover for individual tree species:
  - <5 inches d.b.h.
  - >5 inches d.b.h.

For shrubs, forbs, and grasslike plants:

- Life form
- Vitality
- Canopy cover for each life form
- Canopy cover for dominant species and bear food plant species for the entire stand
- Structural layer (0-1.5 ft, 1.5-6.1 ft, 6.1 ft +) of each taxa

We sampled stands in the grass-forb and shrub-seedling stages in 1984 and will sample stands in the midsuccessional stages (sapling, pole, and young) in 1985. Published values for canopy cover and constancy were used to describe mature and old-growth forest stands (Pfister and others 1977).

Analysis of the field data and interpretation of the resulting community type map as grizzly bear habitat occur in three stages, which are described in the following paragraphs. Because this study is ongoing, an example of a community classification will be presented in the Results section and other elements of the analysis will be discussed hypothetically in the Discussion section.

Community Type Classification

Stand data are examined and stands classified to community types. Cornell ecology programs TWINSPAN (Hill 1979a) and DECORANA (Hill 1979b) are used for the initial data sorting and classification. Species presence and canopy cover are the criteria used. Subjective evaluation of stand location, history, treatment, and other factors is also used to make successive groups of stands and a final classification (Gauch 1982; Pfister and Arno 1980).

Determining Grizzly Bear Food Habits

As a second step in the analysis, grizzly bear foods are determined from the literature and from scat records compiled from the study area and adjacent areas.

Interpretation of Community Types as Grizzly Bear Habitat

The final step is constructing a spatiotemporal model of grizzly bear habitat use based on community type distribution, food habits data, and food availability. Bear foods are ranked in importance by 1-month intervals. The presence and abundance of foods are then compared among community types, and community types are ranked in importance as foraging areas to grizzly bears.

RESULTS

Community Type Descriptions

The following community type (c.t.) classification and community type descriptions are preliminary. Community boundaries were determined from perceived environmental and structural differences. The descriptions that follow highlight major differences in dominant species. Sixteen c.t.'s were identified in the analysis of 131 stands. For brevity, only 2 of the 16 c.t.'s will be described here; all 16 are used in the analysis. A dichotomous key to the c.t.'s is presented in appendix A-1. Physical data are presented in appendix B-1. Stand data are not included for brevity. In the descriptions that follow, terms are defined as follows: present = 0 percent, common = 1 percent, well represented = 5 percent, abundant = 25 percent (after Pfister and others 1977).

The c.t.'s in this analysis fall within the *Abies lasiocarpa*/*Clintonia uniflora* habitat type. Within the study area considerable human-caused disturbance has occurred, including various silvicultural treatments and road-building. Natural disclimaxes include avalanche chutes and areas affected by wildfire. Only stands in the earlier successional stages (grass-forb and shrub-seedling stages) are presented to simplify the presentation of the relevant concepts. These concepts include (1) the nature of the community type classification, (2) the possibilities for interpreting community types as grizzly bear habitat, and (3) the potential for understanding how grizzly habitat may be created or enhanced by land management practices.

1. *Alnus sinuata*/*Claytonia lanceolata* c.t. (n=5): This community type is created by overstory removal. Elevation ranges from 3,800 to 4,350 ft and aspect is predominantly easterly. Tree overstory is generally depauperate. The shrub overstory is strongly dominated by alder (mean cover, 59 percent). *Acer glabrum* is also well represented, as is *Rubus parviflora*. *Vaccinium globulare* is common in most stands (70 percent). *Claytonia lanceolata* is abundant (27 percent), and *Smilacina racemosa* is common in all stands in the understory.

2. *Salix* spp./*Symphoricarpos albus* c.t. (n=8): Tree regeneration is good in this community type following clearcutting. Overstory constancy is moderate to high, and canopy cover is generally greater than 5 percent. The shrub overstory is dominated by *Salix scouleriana*; the shrub midstory is dominated by *Symphoricarpos albus*. Most other shrub species common to the study area are also present. Dominant forbs in the understory include *Epilobium angustifolium*, *Smilacina stellata*, and *Viola glabella*.

DISCUSSION

Vegetation that is disturbed from its climax condition is highly complex and variable. This complexity is usually greater the younger the stand is successionally (Hurschle and Hironaka 1980). Environmental variability as expressed by the vegetation can be understood by systematic classification of habitat types and community types. Stands of similar habitat type, structure, and species composition are grouped together, which permits identification of environmental and habitat differences. An animal's use of habitat can then be quantified.

The theoretical framework of our interpretation is perhaps best understood if viewed graphically (fig. 1). The analysis is composed of three parts: (a) food habits analysis, (b) food plant availability, and (c) the ranking of community types based on percent constancy and percent canopy cover of "preferred" food items. Each of these factors is assessed at an interval of time (for example, 1 month, 2 weeks). The prediction of c.t. importance value ("c" in fig. 1) is thus incremental through the foraging seasons (here denoted as "premast," "mast," and "postmast" seasons).

Certain assumptions are made in this analysis:

1. The importance value of food items determined from scat analysis accurately reflects the importance of that food item to the bear in that time period.
2. The food item availability in a particular c.t. is correctly predicted by phenological data.
3. A grizzly bear "selects" discrete c.t.'s based on the constancy and abundance of preferred plant food items, regardless of c.t. size.

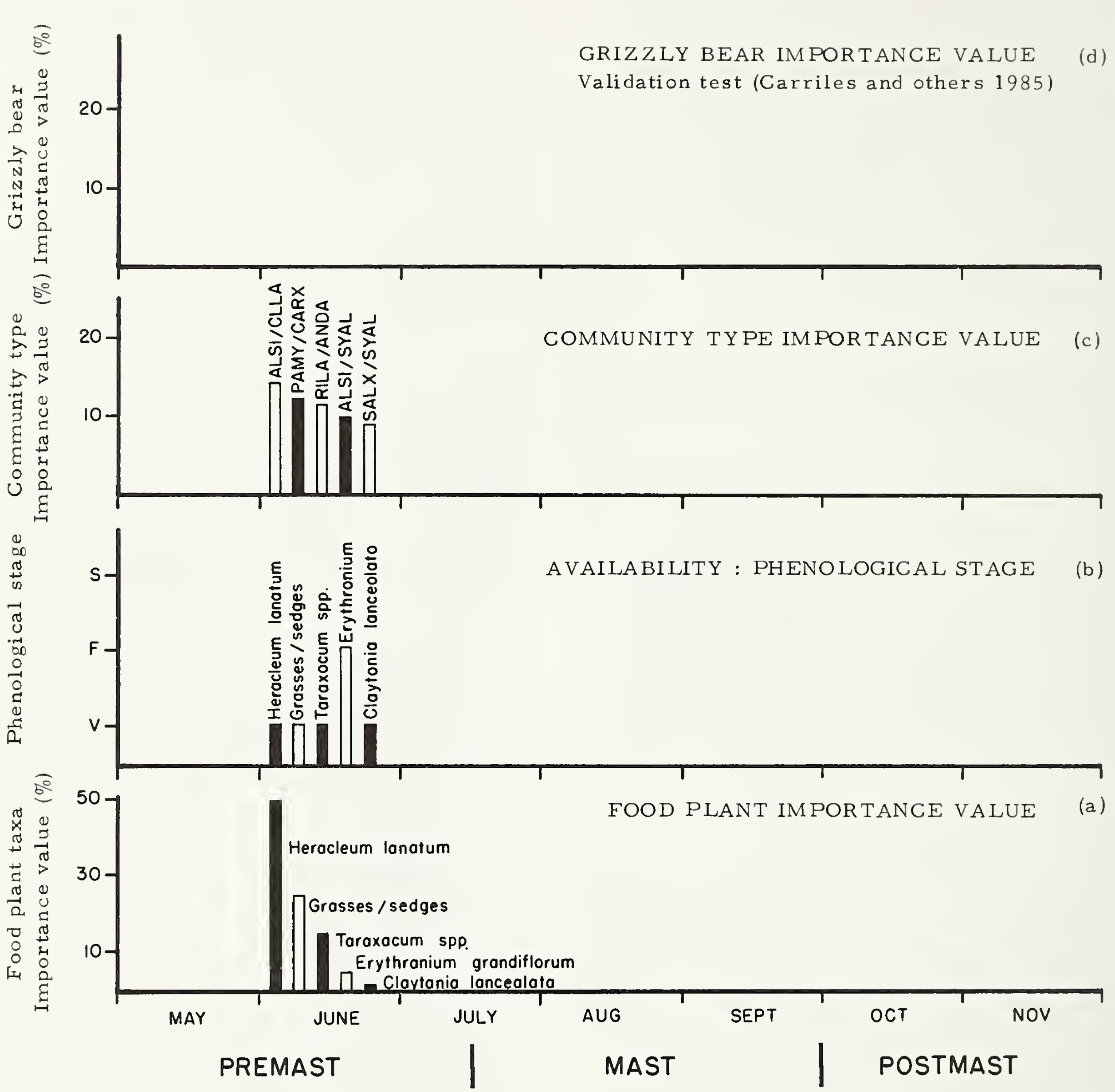

Figure 1.--The theoretical framework for the analysis, interpretation, and testing of community types (c.t.'s) as predictors of grizzly bear habitat suitability. The period of analysis is June. (a) Five bear foods are ranked by importance value. (b) Phenological availability (v = vegetative stage, f = flowering stage, s = seed set stage). (c) Community type importance value determined from food species importance value and phenological availability. Predictions of temporal and spatial use of habitat are made from subjective interpretations of (c). (d) Model predictions are tested in a separate study, using radio-location points; results are used to refine model predictions (Carriles and others 1985).

Figure 1 was constructed from actual and hypothetical data to illustrate the method of analysis. These values are determined as follows:

Food plant taxa importance value percentages (IV percent) are calculated first. Importance value is calculated from the percent frequency and percent volume of food items in scat material. The specific formula is:

$$\text{IV \%} = \frac{(\text{Frequency \% x Volume \%})}{(\text{Frequency \% x Volume \% / 100})} \times 100$$

Only those food items with an importance value of more than 1 percent are used in the subsequent ranking of c.t.'s. The following tabulation presents selected plant food species (from Mace 1984) and hypothetical importance values for the month of June:

Taxa	IV Percent
Heracleum lanatum	50
Grasses and sedges	25
Equisetum spp.	15
Taraxacum spp.	5
Erythronium grandiflorum	3
Claytonia lanceolata	1
Other forbs	1

Phenological availability of important taxa (fig. 1b) is determined next (Carriles in preparation). Phenological availability is strongly modified by elevation and aspect. In this example, it is expressed by three stages: vegetative growth, flowering, and seed set. As figure 1 shows, all taxa are available in the vegetative state in June, with the exception of Erythronium grandiflorum, which is flowering. Availability takes a value of 0 or 1,000 (absent or available, respectively; multiplying by 1,000 results in a linear transformation of the data).

Taxa constancies and canopy cover values summarized from field data are obtained from c.t. summary tables. The following data are derived from plant taxa in the Alnus sinuata/Claytonia lanceolata c.t. of the Abies lasiocarpa habitat type, southern Whitefish Range study area (N = 5).

Trees:

Abies lasiocarpa	5(12)[1,2]
Picea engelmanni	5(2)
Pinus monticola	2(1)
Populus trichocarpa	2(1)

Shrubs:

Acer glabrum	7(15)
Alnus sinuata	10(59)
Amelanchier alnifolia	2(3)
Lonicera involucrata	2(3)
Lonicera utahensis	2(3)
Menziesia ferruginea	2(1)
Oplopanax horridum	2(1)
Pachistima myrsinites	7(3)
Ribes lacustre	7(3)
Rubus parviflora	10(6)
Salix spp.	2(8)
Sambucus racemosa	10(4)
Sorbus spp.	10(16)
Vaccinium globulare	7(2)

Graminoids:

Gramineae	10(8)
Luzula parviflora	2(3)

Forbs:

Achillea millefolium	2(0)
Anaphalis margaritacea	2(3)
Angelica dawsonii	5(3)
Arnica latifolia	2(35)
Athyrium felix-femina	10(7)
Claytonia lanceolata	7(27)
Clintonia uniflora	5(2)
Disporum hookeri	5(9)
Epilobium angustifolium	5(14)
Erythronium grandiflorum	7(13)
Frageria virginiana	2(8)
Galium trifolium	5(2)
Heracleum lanatum	10(6)
Osmorhiza chilensis	7(5)
Pedicularis bracteosa	2(1)
Pteridum aquilinum	5(4)
Senecio triangularis	7(4)
Smilacina stellata	5(3)
Streptopus amplexifolius	2(3)
Taraxacum spp.	2(8)
Tellima grandiflorum	2(25)
Thalictrum occidentale	7(4)
Tiarella trifoliata	2(3)
Urtica dioica	5(3)
Veratrum viride	10(3)
Viola glabella	10(25)

[1]First figure indicates percent constancy: 0 = 0-5, 1 = 5-15, 2 = 15-25, 3 = 25-35, 4 = 35-45, 5 = 45-55, 6 = 55-65, 7 = 65-75, 8 = 75-85, 9 = 85-95, 10 = 95-100
[2]Figure in parentheses indicates percent canopy cover.

The c.t. importance value (CTIV) is calculated using importance value percents (IV percent) of "preferred" foods, canopy cover, constancy, and phenological availability. With these values the c.t. importance value is calculated as follows for all taxa:

$$CTIV = \Sigma\{(\%\text{ canopy cover} \times \%\text{ constancy}) \times (\text{IV }\%)(\text{availability})\}$$

Values are summed across all taxa in the time period with an IV percent greater than 1. A relative CTIV is calculated by dividing individual CTIV's by the sum of all CTIV's for the habitat type and then multiplying by 100.

Table 1 presents importance values and ranks for all 16 c.t.'s in the Abies lasiocarpa/Clintonia uniflora habitat type. During June, Heracleum lanatum and grasses are the most important food items.

The IV percent for grasses, as determined from our hypothetical data, was 25 (see list in Methods); however, calculations of CTIV's with grasses held at this value produced intuitively meaningless results. All c.t.'s contain grasses with moderate-to-high cover and constancy values. When these grass values are calculated, differences between c.t.'s, based on more important diagnostic and bear foods, become obscured. For this reason the IV percent for grasses was uniformly reduced by two thirds. The resulting calculations (table 1) discriminate more between c.t.'s. Other studies have eliminated grasses from calculations altogether for similar reasons (for example, Mace 1984). Even when reduced, however, grasses continued to strongly influence the ranking of types.

Table 1.--Calculated community type importance values (CTIV), and relative importance values for 16 community types (c.t.) in the Abies lasiocarpa/Clintonia uniflora h.t., southern Whitefish Range study area

Taxa	Community type															
	VAGL/ XETE	XETE/ CAAP	ACGL/ MEFE	ALSI/ SYAL	ALSI/ CLLA	SALX/ SYAL	SALX/ CARX	SALX/ THOC	PAMY/ SMST	PAMY/ CARX	ANDA/ SETR	MEFE/ VAGL	RILA/ ATFE	RILA/ ANDA	MEFE/ EPAN	MEFE/ GYDR
Heracleum lanatum	-	-	5.00	38.05	29.25	3.00	-	0.38	12.52	28.52	16.08	0.38	14.63	10.50	3.00	10.50
Grasses and sedges	4.04	21.55	.25	20.79	6.44	41.75	10.19	18.81	7.57	33.80	24.13	4.79	24.93	44.88	20.11	13.20
Equisetum spp.	-	-	-	.90	-	6.10	-	.90	.90	6.00	1.80	-	2.70	11.90	-	-
Taraxacum spp.	-	-	-	-	.40	-	-	.04	.03	-	-	-	.10	.30	.01	.04
Erythronium grandiflorum	.75	1.74	4.14	3.78	2.34	-	-	-	.12	-	.96	.01	-	-	.02	.45
Claytonia lanceolata	-	.01	2.44	.50	1.62	-	-	-	.02	-	.04	.03	-	-	-	.09
IV total	4.79	23.30	11.83	64.02	83.06	50.85	10.19	20.51	21.16	68.32	43.01	5.21	42.36	67.58	23.14	34.78
Relative percent IV	0.8	4.1	2.1	11.2	14.4	8.9	1.8	3.6	3.7	11.9	7.5	0.9	7.4	11.7	4.0	6.1
Rank	16	9	13	4	1	5	14	12	11	2	6	15	7	3	10	8

The results of the c.t. ranking (table 1) are intuitively acceptable to a degree. The five top-ranked c.t.'s fit our preconceived notion of rank, but the order of rank within those five did not. The Alnus sinuata/Symphoricarpos albus c.t. (rank 4) is similar to the Alnus sinuata/Claytonia lanceolata c.t. (rank 1). Heracleum lanatum, the "preferred" food item, is more abundant in the former. Here the abundance of grasses in the ALSI/CLLA c.t. resulted in a decided difference in rank. From what little is known about grizzly bear food habits and the combination of variables that grizzly bears "select" for, such a ranking could be representative.

It may well be that grizzly bear use of c.t.'s will exhibit a "breaking function" where c.t. use falls off rapidly at some certain low value of the product of constancy and cover. The model assumes that this is the case; however, no data exist to indicate where this point lies. The CTIV formula can be modified to account for such an effect once identified. The values in table 1 represent a fraction of the values that would be calculated for the study area. Other habitat types would be evaluated in the same way, and their CTIV's compared against all others. A breaking function phenomenon would greatly reduce the number of c.t.'s in the analysis.

A final ranking of c.t.'s would result in a number of c.t.'s, or "complexes" of c.t.'s (Mace 1984), for each period of analysis. These c.t.'s, ranked in importance by time period and arranged along the horizontal axis of figure 1c for all foraging seasons, would constitute a habitat use model. The validity of such a model rests on its being able to predict bear use of a particular c.t. at a particular time, regardless of whether all stands of that type are used. This is because the proportion of stands of a particular c.t. used may reflect bear numbers or social partitioning of habitat. A resource in excess does not necessarily imply that the resources provided by that c.t. are any less vital to the animal (Lyon 1985).

Finally, these predictions can be readily tested by radio-collaring a significant portion of a local population in a mapped area. Alternately, accurate historical radio-telemetry data could be used to validate predictions and improve model performance for management purposes (Carriles and others 1985).

CONCLUSIONS

Various methods of interpreting the foraging quality of grizzly bear habitat have been devised (for example, Madel and Christensen 1982; Craighead and others 1982; Mace 1984). In general, however, these interpretations remain the weakest part of our understanding of grizzly bear-habitat dynamics. In the Scapegoat Mountains, Craighead and others (1982) based their interpretations on observed bear behavior and are reliably accurate. The method employed in mapping and assessing habitat in the remainder of the Northern Region of the National Forest System (the grizzly bear habitat component system; Zager and others 1980) was based on bear locations, feeding sites analyses, and food habits. Subsequent work, however, relied upon these data, which were extrapolated to areas that were remote from their place of origin (for example, Madel and Christensen 1982).

The recently developed cumulative effects model (CEM) for the Yellowstone Ecosystem (USDA Forest Service 1985) attempts to assimilate habitat quality interpretations into a dynamic model that makes predictions about the effects of human activities on the bear. This modeling effort relies on an extensive data base spanning some 25 years. A similarly designed CEM is being developed for the northern ecosystem without such

an extensive data base. Nevertheless, cumulative effects modeling holds great potential for coming to grips with an often acrimonious debate over the grizzly bear and resource use.

We have attempted to illustrate the utility of presenting grizzly bear habitat as a mosaic of ecologically and hierarchically defined community types. An advantage of this approach is the possibility of improving predictions as additional information becomes available. Improved plant phenological data will enable better assessment of c.t.'s at different elevational zones. Radio-telemetry data should reveal not just point locations but the mosaic of c.t.'s or characteristics actually sought by the bear (Lyon 1985; Carriles and others 1985). Behavioral data obtained from radio-locations will suggest the social mechanisms enforcing any particular partitioning of resources by age or sex class. Tendencies for bears to migrate to seasonally abundant food sources (for example, grizzly bear concentrations on Apgar Mountain in Glacier National Park; Kendall 1984) can also be interpreted and incorporated into the model.

The CEM is a useful evaluation tool. It is important to use reliable data in its construction and refinement. In this paper we have proposed that the basis for obtaining these data is through developing and interpreting ecological vegetation maps. An ecological taxonomy provides a solid foundation for current work and improvements into the future.

ACKNOWLEDGMENTS

This research has relied upon the assistance and generosity of several institutions, businesses, and individuals. In particular, we would like to thank Winter Sports, Inc., of Whitefish, MT, and the National Rifle Association, Washington, DC, for financial support; the Border Grizzly Project, University of Montana, Missoula, for logistical and office support; the Flathead National Forest, particularly Bob Hensler, Dick Call, Carl Hruska, and Bruce Hird, for material and financial support. Peter Stickney, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Missoula, expeditiously verified our plant voucher specimens. The Division of Air, Watershed, and Ecology, Forest Service, Northern Region, Missoula, provided computer time and assistance in classifying community types. Discussions with Mark Haroldson, University of Montana, helped to solidify concepts. We thank Pete Zager for his review and comments. Sarah Prodell generously assisted in typing.

REFERENCES

Arno, S. F.; Simmerman, D. G.; Keane, R. E. Forest succession on four habitat types in western Montana. Gen. Tech. Rep. INT-177. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 74 p.

Carriles, H. Phenology of bear food plants in the Whitefish Range, Montana. Missoula, MT: University of Montana; [in preparation]. M.S. thesis.

Carriles, H.; Haroldson, M.; Hadden, D. Grizzly bear movement and habitat use, southern Whitefish Range, Montana: a test of a predictive model. Research proposal on file at: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Missoula, MT 1985. 15 p.

Cooper, S. K.; Neiman, K; Steele, R. Forest habitat types of northern Idaho. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 295 p. Editorial draft.

Craighead, J. J.; Sumner, J. S.; Scaggs, G. B. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Western Wildlands Institute Monograph No. 1. Missoula, MT. University of Montana Foundation; 1982. 251 p.

Daubenmire, R. Plant communities, a textbook of plant synecology. New York: Harper and Row. 1968. 300 p.

Gauch, H. G. Multivariate analysis in community ecology. New York: Cambridge University Press; 1982. 298 p.

Hann, W. J. A taxonomy for classification of seral vegetation of selected habitat types in western Montana. Moscow, ID: University of Idaho; 1982. 235 p.

Hill, M. O. TWINSPAN: a FORTRAN program for two-way indicator species analysis. Sec. Ecol. Sys. Ithaca, NY: Cornell University; 1979a. 51 p.

Hill, M. O. DECORANA: a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Sec. Ecol. Sys. Ithaca, NY: Cornell University; 1979b. 31 p.

Hurschle, G.; Hironaka, M. Classification and ordination of seral plant communities. J. Range Manage. 33: 179-182; 1980.

Kendall, K. C. Grizzly bear population trend studies, Apgar Mountains, Glacier National Park. 1984. Unpublished paper on file at: U.S. Department of the Interior, National Park Service, Glacier National Park, West Glacier, MT. 23 p.

Lyon, L. J. A discriminant function analysis of habitat selection. Unpublished paper presented at the Ann. Meet. Northwest Sect. Wildl. Soc., 3-5 April 1985, Missoula, MT. On file at: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Forest Sciences Laboratory, Missoula, MT; 1985. 20 p.

Mace, R. D. Identification and evaluation of grizzly bear habitat in the Bob Marshall Wilderness Area, Montana. Missoula, MT: University of Montana; 1984. M.S. thesis. 176 p.

Madel, M; Christensen, A. C. Cumulative effects analysis process and grizzly bear habitat mapping. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1982. 37 p.

Mueggler, W. F.; Stewart, W. L. Grassland and shrubland habitat types of western Montana. Gen. Tech. Rep. INT-66. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 154 p.

O'Brien, R.; Van Hooser, D. D. Understory vegetation inventory: an efficient procedure. Res. Pap. INT-323. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 6 p.

Pfister, R. D.; Arno, S. F. Classifying forest habitat types based on potential climax vegetation. For. Sci. 26(1): 52-70; 1980.

Pfister, R. D.; Kovalchik, B. L.; Arno, S. F.; Presby, R. C. Forest habitat types of western Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Steele, R. An approach to classifying seral vegetation within habitat types. Northwest Sci. 58: 28-39; 1984.

U.S. Department of Agriculture, Forest Service. Cumulative effects. Kalispell, MT: U.S. Department of Agriculture, Forest Service, Flathead National Forest; 1981. 57 p.

U.S. Department of Agriculture, Forest Service. Cumulative effects analysis process for the Yellowstone Ecosystem. 1984. Unpublished draft on file at: U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT: 1985. 43 p.

Zager, P. E.; Jonkel, C. J.; Mace, R. D. Grizzly bear habitat terminology. Spec. Rep. 41, Border Grizzly Project. Missoula, MT: University of Montana; 1980. 13 p.

Appendix A.--Dichotomous key to community types in the ABLA/CLUN habitat type of the southern Whitefish Range study area

A.	Alnus sinuata <2 percent, Sambucus racemosa <2 percent, and Carex spp. ≥2 percent and Xerophyllum tenax ≥5 percent	B	
AA.	Alnus sinuata and Sambucus racemosa >2 percent, Carex spp. <2 percent, or Menziesia ferruginea ≥5 and Vaccinium globulare >2 percent	C	
B.	Calochortus apiculatus ≥2 percent, Pinus monticola absent	B	Xerophyllum tenax/Calochortus apiculatus c.t.
BB.	Pinus monticola present and Calochortus apiculatus absent, then also Vaccinium globulare ≥2 percent	BB	Vaccinium globulare/Xerophyllum tenax c.t.
C.	Smilacina stellata ≥2 percent with Menziesia ferruginea <5 percent and/or Symphoricarpos albus <1 percent	D	
CC.	Smilacina stellata <2 percent, Menziesia ferruginea ≥5 percent, and Symphoricarpos albus <1 percent	K	
D.	Larix occidentalis absent and/or Salix spp. absent, Alnus sinuata >10 percent, and Pachistima myrsinites <5 percent	E	
DD.	Larix occidentalis present and/or Salix spp. present, Alnus sinuata ≤10 percent, and Pachistima myrsinites ≥5 percent	G	
E.	Menziesia ferruginea ≥2 percent and Acer glabrum ≥20 percent	E	Acer glabrum/Menziesia ferruginea c.t.
EE.	Menziesia ferruginea <2 percent with Acer glabrum <20 percent	F	
F.	Vaccinium globulare absent, Claytonia lanceolata <2 percent, and Pachistima myrsinites <2 percent	F	Alnus sinuata/Symphoricarpos albus c.t.
FF.	Vaccinium globulare ≥1 percent, Claytonia lanceolata ≥2 percent, and Pachistima myrsinites ≥2 percent	FF	Alnus sinuata/Claytonia lanceolata c.t.
G.	Gymnocarpium dryopteris and Heracleum lanatum absent	H	
GG.	Gymnocarpium dryopteris and Heracleum lanatum both present, Pachistima myrsinites generally present	J	
H.	Clintonia uniflora absent, or Ranunculus uncinatus and Symphoricarpos albus ≥2 percent with Salix spp. ≥2 percent	H	Salix spp./Symphoricarpos albus c.t.
HH.	Clintonia uniflora present and Salix spp. ≥2 percent	I	
I.	Arnica latifolia and Thalictrum occidentale <2 percent, Anaphalis margaritacea absent; Carex spp. ≥2 percent	I	Salix spp./Carex spp. c.t.
II.	Arnica latifolia and Thalictrum occidentale ≥2 percent, Anaphalis margaritacea present	II	Salix spp./Thalictrum occidentale c.t.

J.	Smilacina racemosa present and Epilobium angustifolium ≥2 percent with Pachistima myrsinites ≥2 percent	J	Pachistima myrsinites/ Smilacina stellata c.t.
JJ.	Smilacina racemosa and Populus trichocarpa absent and Carex spp. ≥5 percent	JJ	Pachistima myrsinites/ Carex spp. c.t.
K.	Equistum spp. <1 percent and Pachistima myrsinites or Gymnocarpium dryopteris present	M	
KK.	Equisetum spp. ≥1 percent, Pachistima myrsinites and Gymnocarpium dryopteris generally absent, and Angelica dawsonii present	L	
L.	Streptopus amplexifolius present and Luzula parviflora present with Ribes lacustre ≥2 percent	N	
LL.	Streptopus amplexifolius absent and Habenaria spp. and Gymnocarpium dryopteris absent	LL	Angelica dawsonii/Senecio triangularis c.t.
M.	Ribes lacustre and/or Rubus parviflora present, and/or Epilobium angustifolium ≥2 percent	O	
MM.	Ribes lacustre, Rubus parviflora or Epilobium angustifolium absent; Menziesia ferruginea ≥5 percent and Vaccinium globulare ≥2 percent	MM	Menziesia ferruginea/Vaccinium globulare c.t.
N.	Athyrium felix-femina, Gymnocarpium dryopteris and Tiarella trifoliata present	N	Ribes lacustre/Athyrium felix-femina c.t.
NN.	Athyrium felix-femina, Gymnocarpium dryopteris, and Tiarella trifoliata absent	NN	Ribes lacustre/Angelica dawsonii c.t.
O.	Xerophyllum tenax ≥2 percent and Gymnocarpium dryopteris <2 percent with Alnus sinuata ≥2 percent	O	Menziesia ferruginea/Epilobium angustifolium c.t.
OO.	Xerophyllum tenax <2 percent, and Gymnocarpium dryopteris ≥2 percent with Menziesia ferruginea ≥2 percent	OO	Menziesia ferruginea/ Gymnocarpium dryopteris

Appendix B.--Summary of physical data for some community types in the *Abies lasiocarpa*/*Clintonia uniflora* habitat type in the southern Whitefish Range study area

Community type	Elevation (ft) (Min-Max)	Elevation (ft) Mean	Aspect (degrees) (Min-Max)	N
Xerophyllum tenax/ *Calochortus apiculatus*	(4,050-6,000)	5,220	(78-260)	6
Vaccinium globulare/ *Xerophyllum tenax*	(5,550-6,775)	6,171	(110-145)	6
Acer glabrum/ *Menziesia ferruginea*	(4,700-5,300)	4,944	(240-270)	4
Alnus sinuata/ *Symphoricarpus albus*	(4,350-5,450)	4,900	(135-200)	2
Alnus sinuata/ *Claytonia lanceolata*	(4,050-5,350)	4,938	(55-150)	4
Salix spp./ *Symphoricarpus albus*	(3,800-4,350)	4,069	(80-355)	8
Salix spp./ *Carex* spp.	(3,900-4,900)	4,275	(55-240)	5
Salix spp./ *Thalictrum occidentale*	(4,150-5,200)	4,682	(60-220)	7
Pachistima myrsinites/ *Smilacina stellata*	(3,800-5,900)	4,308	(20-350)	29
Pachistima myrsinites/ *Carex* spp.	(4,300-4,600)	4,450	(140-180)	2
Angelica dawsonii/ *Senecio triangularis*	(5,300-6,200)	5,750	(25-125)	2
Menziesia ferruginea/ *Vaccinium globulare*	(3,925-5,400)	4,765	(25-165)	5
Ribes lacustre/ *Athyrium felix-femina*	(5,150-5,650)	5,406	(10-360)	4
Ribes lacustre/ *Angelica dawsonii*	(4,950-5,400)	5,285	(15-360)	5
Menziesia ferruginea/ *Epilobium angustifolium*	(4,350-5,650)	5,228	(18-270)	19
Menziesia ferruginea/ *Gymnocarpium dryopteris*	(4,625-6,200)	5,280	(10-360)	23

GRIZZLY BEAR FOOD RESOURCES IN THE FLOOD PLAINS AND AVALANCHE CHUTES

OF THE BOB MARSHALL WILDERNESS, MONTANA

Richard D. Mace and Gael N. Bissell

ABSTRACT: The vegetative composition of avalanche chutes and flood plains was investigated in the Bob Marshall Wilderness. Within these two components, 14 distinct vegetation types (VT) were identified, described, and ranked according to forage value. For herbaceous food items, the riparian Picea flood plain VT and the Alnus spp. avalanche chute VT ranked highest in forage value. For fruit items, the terrestrial Picea (flood plain) and xeric herbaceous fan (avalanche) VT's ranked highest. The sand bar (flood plain) and xeric (avalanche) VT's ranked highest for modified stems.

INTRODUCTION

Flood plains and avalanche chutes comprise two major grizzly bear foraging habitat components in the Northern Continental Divide Ecosystem (Mealey and others 1977; Zager 1980). Results of grizzly bear research in the northern Rocky Mountains have shown grizzly bears utilize these two components of habitat throughout the spring, summer, and autumn (Singer 1978; McLellan 1982).

The vegetative structure and composition of both flood plains and avalanche chutes are exceedingly complex due to the interactions and gradients of moisture, elevation, aspect, slope, soils, and succession. The complexity of these two components confounds predictions of foraging habitat quality. Because such predictions are important to grizzly bear management, we investigated in detail the vegetative structure and composition of flood plain and avalanche chute complexes. This project was part of an effort to evaluate grizzly bear habitat in the Bob Marshall Wilderness (Mace 1984 and this volume). The specific objectives of this project were (1) to describe in detail the vegetative composition of the major vegetation types within flood plains and avalanche chute components in the southern Bob Marshall Wilderness; (2) to evaluate the grizzly bear food resource within each vegetation type for three foraging strategies; and (3) to rank vegetation types according to their greatest forage value to the grizzly bear. The results and discussion of the flood plain and avalanche chute components are provided separately.

STUDY AREA DESCRIPTION

The study area is located in the southern portion of the Bob Marshall Wilderness and comprises 40 400 ha (fig. 1). The region is dominated by rugged mountain topography and dissected by numerous streams and one major river system, the South Fork of the Flathead River. The principal drainages include Gordon, Babcock, and Youngs Creeks, which flow westerly into the South Fork.

The vegetation of the region is strongly influenced by the Pacific maritime climate (Daubenmire 1969). As major Pacific air masses move through the region, much of the precipitation (rain and snow) is deposited on or near the Swan Mountain range (west boundary of the study area); however, in the southern Bob Marshall, some of this precipitation is lost to the Mission Mountain range. As a result, the southern Bob Marshall appears drier than northern portions. The distribution of avalanche chutes is also associated with moisture deposition patterns; most avalanche chutes in the study area are located close to the Swan Divide. The primary forest habitat types (h.t.) of the study area are within the spruce (Picea spp.), Douglas-fir (Pseudotsuga menziesii), and subalpine fir (Abies lasiocarpa) series (Pfister and others 1977). Stands of subalpine larch (Larix lyallii) are found above 2 000 m.

METHODS

Field Procedures

Field work was conducted from June through September of 1982 and 1983. Following reconnaisance efforts, major vegetation types of the flood plains and avalanche tracts were delineated based on dominant plant species and vegetation structural characteristics. Vegetation types were subdivisions of the total habitat component flora and were distinguished by obvious spatial arrangements, physiognomic characteristics, and the existing composition of the vegetation.

Following this stratification, plots were placed randomly within each of these vegetation types.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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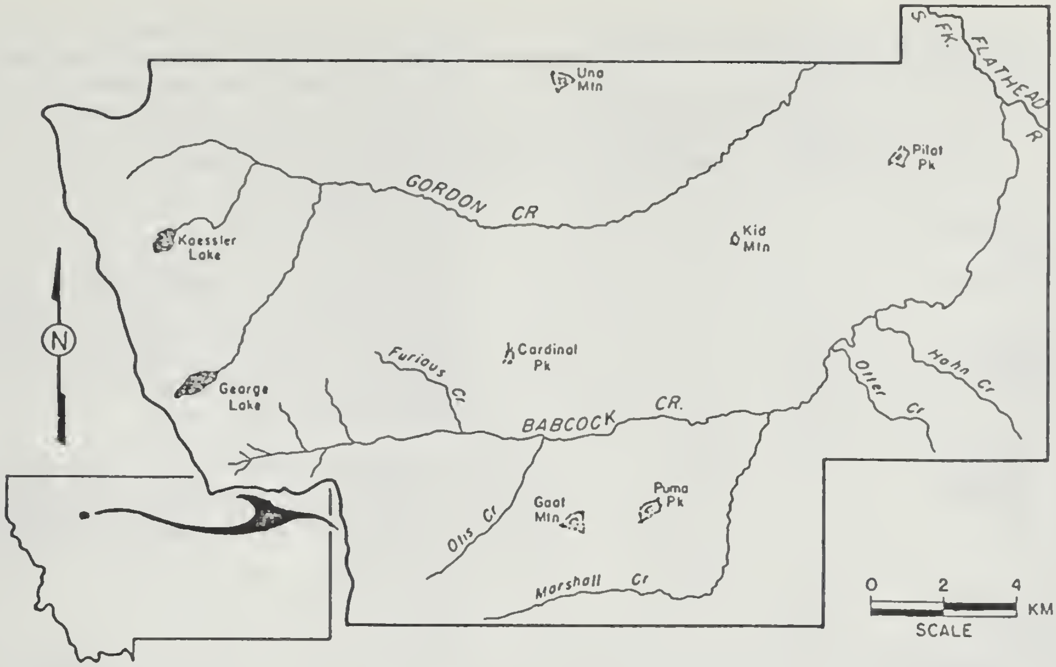

Figure 1.--The study area.

Flood plains were sampled using 375-m^2 (or 1/10-acre) circular plots; avalanche tracts were sampled using 5-m^2 circular plots. The larger plots were selected for the flood plain because this component included timbered vegetation types.

The number of plots taken in each vegetation type was determined by constructing a species-area-curve (Mueller-Dumbois and Ellenberg 1974). Sampling was completed when no new taxa were encountered after three consecutive plots were taken. Complete taxa lists were compiled, although grasses and sedges were combined. Cover values for taxa, nonvascular material, and unvegetated portions were ocularly estimated using the modified Daubenmire cover classes of Pfister and others (1977): 0=absent; T=trace-1 percent; A=1-5 percent; B=5-25 percent; C=25-50 percent; D=50-75 percent; E=75-95 percent; F=95-100 percent. For all plots, tree, shrub, and herbaceous cover per stratum (0-0.9 m; 0.9-2 m; >2 m) were recorded.

Botanical nomenclature followed Hitchcock and Cronquist (1973). Timbered sites were keyed to the appropriate forest habitat type of Pfister and others (1977).

Analytical Procedures

Plant specimens were verified by Peter Stickney (Intermountain Research Station, Missoula, MT). Vegetation data were then assembled into association tables to scrutinize relationships among plots (Mueller-Dombois and Ellenberg 1974). Plot data were entered into a DEC-20 computer to calculate species percent occurrence and average and relative percent covers. Using SP55 programs (Nie and others 1975).

Average percent cover was derived by summing the cover class midpoints for each species and then dividing the summation by total number of plots in the vegetation type. This value was then converted to relative percent cover by converting the total vegetative and nonvegetative covers to 100 percent. The percent occurrence values were also determined for each taxa.

A list of major food plants in the study area was collated using recent literature on grizzly bear food habits from the Northern Rocky Mountains of the United States and southern British Columbia, Canada (Russell and others 1979; Aune and Stivers 1982; Craighead and others 1982; Sumner and Craighead 1973; Mace and Jonkel in press). Food items were placed into one of three major food categories; succulent vegetation, modified stems (roots, bulbs, or corms), or fruit. Each food item was given a seasonal preference rank of 1, 2, or 3, with 3 as high level of use and 1 as low, based on levels of use indicated in the aforementioned studies (table 1).

To quantitatively compare the overall foraging value of the major vegetation types with one another (within both flood plain and avalanche chute components), importance values were calculated using the absolute percent cover of certain bear food items and the preference ranks. First, a "food item importance value" was obtained for each sample plot by multiplying the midpoint of the coverage class for each food item times the food item preference rank. Second, a "vegetation type importance value" was obtained by summing the food item importance values for each plot and then dividing by the total number of plots to obtain the average vegetation type importance value.

Table 1.--Grizzly bear food items and preference ranks used in determining vegetation type importance values

Species	Preference value: Herbaceous	Modified stems	Fruit
FORBS:			
Achillea millefolium	1	2	
Allium cernuum		2	
Allium schoenprasum		2	
Allium spp.			
Angelica arguta	3		
Aster conspicuus	1		
Aster foliaceus	1		
Aster occidentalis	1		
Aster spp.	1	2	
Astragalus alpinus		2	
Astragalus bourgovii		2	
Astragalus robbinsii		2	
Astragalus spp.			
Castilleja spp.	1		
Cirsium spp.	2	3	
Claytonia lanceolata			
Equisetum arvense	3		
Equisetum spp.	3	3	
Erythronium grandiflorum			
Fragaria virginiana	3		
Hedysarum occidentale		2	
Heracleum lanatum	3		
Ligusticum canbyi	2		
Ligusticum spp.	2	1	
Lomatium dissectum		3	
Lomatium cous		3	
Lomatium macrophyllum		3	
Lomatium sandbergii		3	
Lomatium spp.			
Osmorhiza chilensis	3		
Osmorhiza purpurea	3		
Osmorhiza occidentalis	3		
Osmorhiza spp.	3	3	
Oxytropis campestris		2	
Polygomum bistortoides			
Senecio triangularis	2		
Trifolium spp.	3		
Taraxacum spp.	3		
Valeriana sitchensis	2		
Valeriana occidentalis	2		
Veratrum viride	2		
SHRUBS:			
Amelanchier alnifolia			3
Arctostaphylos uva-ursi			2
Cornus stolonifera			2
Prunus virginiana			2
Rhamnus alnifolia			2
Ribes lacustre			1
Ribes viscosissimum			1
Ribes inerme			1
Ribes hudsonianum			1
Ribes spp.			1
Rosa acicularis			1
Rosa woodsii			1
Rosa spp.			1
Rubus idaeus			1
Rubus spp.			1
Shepherdia canadensis			3
Sorbus scopulina			3
Vaccinium scoparium			2
Vaccinium caespitosum			2
Vaccinium globulare			3

Analyses were accomplished for three foraging categories: herbaceous, modified stems, and fruits. Vegetation type importance values were then ranked on an ordinal scale for each foraging strategy. To compare the similarity between vegetation types sampled from different avalanche tracts, coefficients of percent species similarity (Jaccard 1912) were calculated. These similarity coefficients were calculated excluding ephemeral taxa because not all areas were sampled at the same time of year nor within the same year. These coefficients were also calculated using only grizzly bear foods. Genera and species of a given genera were considered different taxa in these analyses. The following formula was used for percent taxa similarity:

$$= \frac{\text{Number of taxa common to both locations (A and B)}}{\text{Number of taxa unique to location A + number of taxa unique to B + number of taxa common to both locations}}$$

RESULTS

Description of Flood Plain Vegetation Types

To comply with other classification systems for valley bottom lands, the flood plains of the study area were divided into two distinct zones (U.S. Department of Agriculture 1978; Pfister and Batchelor 1984). The riparian zone was adjacent to the river channel and susceptible to annual and periodic inundation. The terrestrial zone was that area of terraced valley floor not subjected to flood waters. The terrestrial zone corresponded to relatively flat benches on older alluvium above the riparian zone. Vegetation composition in both zones reflected water table depth, frequency of flood and natural fires, subtle gradients of elevation and temperature, and soil type and depositional pattern. Illustrations of several flood plain vegetation types are presented in figures 2 to 4.

Riparian Zone.--Six vegetation types were identified for the riparian zone of major flood plains. These types represented distinctive seres in the successional pattern on the zone. Each vegetation type was further stratified by its apparent position in the successional process: pioneer, early successional, midsuccessional, late successional, and climax (stable) in convention with Allen (1980).

1. Gravel Bar VT: The gravel bar VT represented the earliest pioneer sere and occupied that portion of the riparian zone directly adjacent to the water channel. Therefore, this vegetation type was inundated during annual spring runoff. Fluvial-deposited pebbles, gravels (approximately 8 inches), and silts supported 30 taxa. Gravel and silt constituted 86 percent of the cover. Dominant taxa were willow (Salix spp.), common willow-weed (Epilobium glandulosum), clover (Trifolium spp.), and purple milk-vetch (Astragalus alpinus) (table 2).

Table 2.--Relative percent cover and occurrence (percent cover/percent occurrence) of dominant taxa within eight flood plain vegetation types

Taxa	Gravel bar	Sand bar	*Salix* flat	Mesic herbaceous meadow	Riparian *Picea*	*P. trichocarpa*	Terrestrial spruce	Xeric graminoid meadow
FORBS:								
Trifolium spp.	[1]t/44	2/15			4/41			
Epilobium latifolium	5/70							
Senecio pseudaureus		1/85	3/62					
Achillia millefolium		1/100				1/100		
Lupinus spp.		2/54					t/44	
Oxytropis campestris		2/46						
Equisetum spp.			5/46	1/77	2/59	t/25		
Heracleum lanatum		t/7	5/73	2/62	1/63			
Fragaria virginiana		1/65	3/85	6/82		3/75		
Thalictrum occidentale				17/85	11/63			
Smilacena stellata				1/92				
Angelica arguta				1/92	t/56	t/25		
Galium triflorum					3/74			
Epilobium spp.						4/75		
Taraxacum spp.						2/25		
Astragalus miser						1/75		
Epilobium angustifolium							1/65	
Erigeron spp.							1/65	
Eriogonum umbellatum								1/50
Geum triflorum								1/55
Penstemon spp.								3/85
Potentilla spp.								2/45
SHRUBS:								
Rosa spp.		3/62	1/77	8/100	2/81		t/4	
Arctostaphylos uva-ursi			2/31			30/50	29/91	
Salix spp.	2/37		42/85	t/23				
Ribes spp.			5/81	1/54	t/26	t/25		
Lonicera involucrata			4/85	2/77	2/74			
Linnaea borealis							t/13	
Cornus stolonifera				2/15	2/52	42/75		
Vaccinium caespitosum							41/91	
Artemisia tridentata								2/20
GRAMINEAE/CYPERACEAE	3/74	11/69	43/100	41/100	15/100	30/75	7/100	26/100
NONVASCULAR COVER	86/100	51/100	1/74	5/54	15/100	25/100	2/13	41/100

[1]t = < 0.5 percent cover.

Figure 2.--Panoramic view of the Youngs Creek flood plain showing the mesic riparian zone adjacent to the river channel and the upland terrestrial zone along the benches.

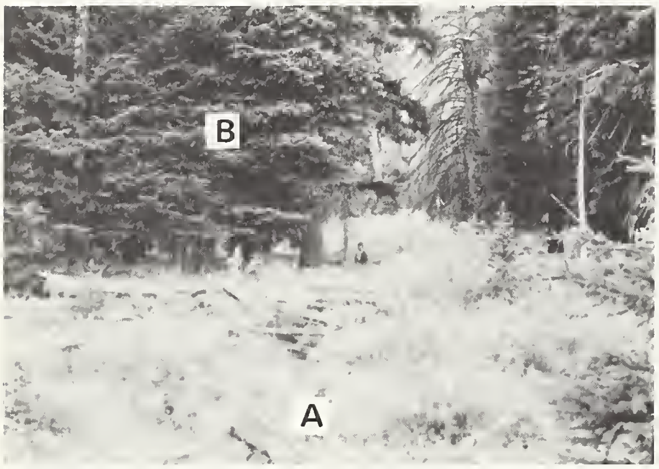

Figure 3.--Mesic herbaceous meadow (A) and riparian *Picea* (B) VT's within the riparian zone of the flood plain complex.

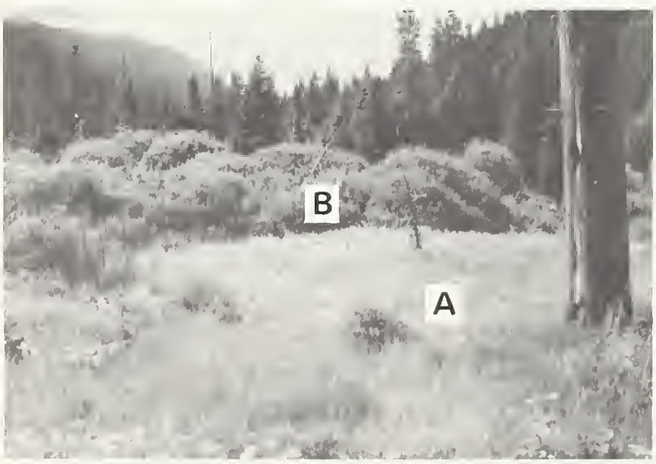

Figure 4.--Sandbar (A) and *Salix* spp. flat (B) VT's within the riparian zone of the flood plain complex.

Several "key" herbaceous foods occurred in this vegetation type but were of trace coverage (table 3). Foods present in this type of the modified stem category included purple milk-vetch, wild onion (*Allium* spp.), and slender crazyweed (*Oxytropus campestris*). Key fruit-bearing taxa were absent in the type.

2. Sand Bar VT. The sand bar VT occurred on fine-grained fluvial sand and silt deposits. This type, although also considered a pioneer sere, was more stable than gravel bars and would only be disrupted by catastrophic floods. Nonvascular cover was 51 percent. Dominant herbaceous taxa of this vegetation type included slender crazyweed, wormleaf stonecrop (*Sedum stenopetalum*), lupine (*Lupinus* spp.), and yellow buckwheat (*Eriogonum flavum*) (table 2).

Twelve key grizzly bear foods occurred in the vegetation type, all of which were of low cover and occurrence. Modified stems such as slender crazyweed, wild onion, and purple milk-vetch were the only conspicuous foods. Grass and sedge cover was 11 percent.

3. *Salix* spp. Flat VT. Shrubfields dominated by willow occupied mesic and hydric river oxbows, narrow margins and adjacent to river channels, and to a lesser extent mesic openings in spruce stands. Thirteen shrub taxa were found in this early successional vegetation type. Willow showed the greatest cover in all strata (42 percent). Black twin-berry (*Lonicera involucrata*) and currant (*Ribes* spp.) were considered codominant with willow in the lower stratum. The dominant herbs (table 2) were cow-parsnip (*Heracleum lanatum*), horsetail (*Equisetum* spp.), and streambank butterweed (*Senecio pseudaureus*). Several grizzly bear food plants exhibited relatively high cover values in willow flats: cow-parsnip, horsetail, and grasses/sedges (Gramineae/Cyperaceae) (table 3).

4. Mesic Herbaceous Meadow VT. Mesic meadows of the riparian zone were complex mosaics of openings and edges within and between spruce, willow, and lodgepole pine (*Pinus contorta*) vegetation. On certain sites, these meadows formed abrupt edges between two or more vegetation types, but on other sites formed a gradual continuum from the adjacent type. Apparently favorable combinations of light, moisture, and temperature led to a high diversity of plant taxa. Grasses (primarily bluejoint reedgrass [*Calamagrostis canadensis*]) and sedges had a combined cover of 41 percent. Western meadowrue (*Thalictrum occidentale*) was the dominant herbaceous species. Other dominant herbs were strawberry (*Fragaria* spp.), cow-parsnip, and mountain arnica (*Arnica latifolia*). Eighteen shrub taxa were recorded in this type, of which red-osier dogwood (*Cornus stolonifera*) and rose (*Rosa* spp.) exhibited the greatest cover values (table 2).

Eleven herbaceous food plants occurred in the mesic herbaceous meadow VT (table 3). Cow-parsnip, horsetail, and angelica (*Angelica arguta*) were key food items of relatively high

Table 3.--Relative percent cover and occurrence (percent cover/percent occurrence) of major bear food items in each vegetation type of the flood plain complex

Taxa	Gravel bar	Sand bar	*Salix* spp. flat	Mesic herbaceous meadow	*P. trichocarpa*	Riparian spruce	Terrestrial *Picea*	Xeric graminoid meadow
HERBACEOUS								
Heracleum lanatum		[1]t/7	5/73	2/62	t/25	1/63		
Angelica arguta			t/65	1/92	t/25	t/56		
Ligusticum canbyi			t/4					
Osmorhiza occidentalis			t/8	t/15				
Equisetum spp.	t/15		5/46	1/77	t/25	2/59		
Gramineae/Cyperaceae	3/74	11/69	43/100	41/100	30/75	15/100	7/100	20/100
MODIFIED STEMS								
Astragalus spp.	t/26	t/19	t/27	t/23	1/75	t/7	t/4	
Oxytropus spp.	t/4	2/40						
Allium spp.	t/4	t/54	t/15	1/31	t/50	t/15	t/13	t/5
Lomatium spp.		t/8						
FRUITS								
Amelanchier alnifolia			t/4	t/8			t/17	
Vaccinium caespitosum							41/91	
Rosa spp.	t/4	3/62	1/77	8/100	1/100	2/81	t/4	t/5
Ribes spp.		t/15	5/81	1/54	t/25	t/26		
Sheperdia canadensis			t/4	1/23	2/75	t/15	9/13	
Cornus stolonifera				2/15	42/75	2/52		

[1]t = < 0.5 percent cover.

cover and occurrence. Red-osier dogwood and species of rose (*Rosa* spp.) were dominant fruit-bearing taxa.

5. *Populus trichocarpa* VT. Small (<1.6 ha) stands of black cottonwood (*P. trichocarpa*) colonized fluvial sand and gravel deposits of the riparian zone. This midsuccessional type, which was sampled just south of Big Prairie, appeared to have been heavily grazed and trampled by domestic livestock. The overstory canopy was a relatively equal mixture of black cottonwood, Douglas-fir, and lodgepole pine. Clover, dandelion (*Taraxacum* spp.), strawberry, and Missouri goldenrod (*Solidago missouriensis*) were dominant herbs. Shrubs with the highest cover and occurrence values included red-osier dogwood, kinnikinnick (*Arctostaphylos uva-ursi*), and buffalo-berry (*Shepherdia canadensis*) (table 3).

6. Riparian *Picea* VT. Three habitat types of the spruce series (Pfister and others 1977) were combined because of similar vegetative qualities. Habitat types within this riparian *Picea* VT included spruce/sweet-scented bedstraw (*Galium triflorum*); spruce/queen's cup (*Clintonia uniflora*) with queen's cup absent, bunchberry (*Cornus canadensis*) present; and spruce/starry false Solomon's seal (*Smilacina stellata*). These habitat types existed as small pockets on poorly drained soils of channel oxbows, and have survived nearly two centuries of natural fire (average stand age of 179 years).

Seventy plant taxa were encountered in plots. Dominant taxa, although variable by habitat type, included western meadowrue, streambank butterweed, showy aster (*Aster conspicuous*), bunchberry (*Pyrola* spp.), and western twinflower (*Linnaea borealis*). Alder (*Alnus* spp.), black twin-berry, and red-osier dogwood were dominant shrubs (table 2). The cover and occurrence of bear food items is given in table 2.

Terrestrial Zone.--Flood plain benches displayed much less vegetation type diversity than the riparian zone. Two vegetation types were sampled in this zone.

1. Terrestrial *Picea* VT. Seral, well-drained phases of the spruce climax series existed as large, relatively homogeneous stands on flat benches above the riparian zone. All stands sampled were renewed following the wildfire of 1926 and corresponded to the spruce/dwarf huckleberry (*Vaccinium ceaspitosum*) h.t. Lodgepole pine was the dominant conifer in all strata. Spruce and Douglas-fir stems were present as regeneration in lower strata.

Thirty-five taxa were in sample plots. Dominant shrubs were dwarf huckleberry, kinnikinnick, and buffalo-berry. All herbaceous taxa displayed trace cover values; however, those with the greatest percent occurrence were fireweed lousewort (*Pedicularis* spp.), fleabane (*Erigeron* spp.), and lupine (table 2). Herbaceous and

modified-stem bear food items were relatively rare in this type. Buffalo-berry and dwarf huckleberry were important fruit-bearing food items (table 2).

2. Xeric Graminoid Meadow VT. Dry meadows of the terrestrial zone were located on large alluvial fans or existed as small openings within the spruce/dwarf huckleberry h.t. This vegetation type exhibited a pronounced seasonal change, from a late spring/early summer flush to severe desiccation by August.

The xeric meadow VT corresponded to the rough fescue-Richardson's needlegrass (*Festuca scabrella-Stipa richardsonii*) community type of Johnson (1982) and the rough fescue-Idaho fescue (*F. idahoensis*) grassland h.t. of Mueggler and Stuart (1980). The big sagebrush (*Artemisia tridentata*) phase of the aforementioned community type was observed on the Hahn Creek alluvial fan.

Grasses and sedges showed a combined relative cover of 26 percent and occurred in all plots. Dominant herbaceous taxa were sulfur buckwheat (*Eriogonum unbellatum*), prairiesmoke avens (*Geum triflorum*), clover, and lupine. Nonvascular ground cover was 41 percent (table 2).

Ranking of Vegetation Type Importance Values by Forage Categories

Herbaceous Forage Category.--Calculations of vegetation type importance values (IV's) for the herbaceous foraging season yielded values from 1 to 54 for eight flood plain vegetation types (table 4). Riparian zone vegetation types generally ranked higher in succulent grizzly foods than did those of the terrestrial zone. The riparian *Picea* VT, a timbered sere, ranked highest of all flood plain types. Openings in the riparian spruce canopy, the mesic herbaceous meadow VT, ranked second. The terrestrial zone (flood plain bench) was negligible in succulent bear foods.

Plants whose underground parts are eaten by grizzly bears were found in all vegetation types, but were of low cover and occurrence. The sand bar VT ranked highest of all types due to the presence of milk-vetch and slender crazyweed. Interestingly, yellow hedysarum (*Hedysarum sulphurescens*), whose roots are extensively eaten in the North Fork of the Flathead River (Singer 1978; McLellan 1982), was observed only once in the flood plain component.

Fruit Forage Category.--The terrestrial *Picea* VT ranked highest of all flood plain types for fruit-bearing shrubs preferred by grizzly bears (table 4). Buffalo-berry and dwarf huckleberry were the primary foods in this type and were of lower cover elsewhere in the flood plain. Buffalo-berry appeared to produce the greatest number of berries in open-timbered stands growing on rocky alluvium. Conversely, dwarf huckleberry stems were more prevalent in highly stocked lodgepole stands and exhibited poor fruit production during the two years of field investigation. Interestingly, this terrestrial *Picea* VT ranked second of all vegetation types in the temperate, subalpine zones of the study area (Mace, this volume).

Mesic herbaceous meadows and the black cottonwood stands ranked second during the fruit forage season. Red-osier dogwood, buffalo-berry, and species of currant were primary foods in these vegetation types. The remaining five vegetation types of the flood plain complex ranked low for this season.

Avalanche Chutes

Seven avalanche chutes were sampled from various dominant aspects (table 5). Six major vegetation types were distinguished in avalanche chutes: (1) streamside; (2) *Alnus* spp. shrubfields; (3) *Xerophyllum tenax*; (4) xeric; (5) mesic herbaceous fan; and (6) xeric herbaceous fan. Several of these vegetation types are illustrated in figures 5 to 7.

Description of Vegetation Types

1. Streamside VT. The streamside VT occurred adjacent to the intermittent and continuously flowing streams of five sampled avalanche tracts. Marshall Creek (north-facing) and Otis Creek (south-facing) did not have streamside VT types. Plots in the streamside VT did not include dense alder shrubfields (described below), although they did include randomly encountered individual shrubs. For all avalanche chutes containing this vegetation type, the streamside VT occupied the least area, ranging from 2 to 8 percent of the entire avalanche chute (table 5).

Dominant herbaceous taxa included arrowleaf groundsel (*Senecio triangularis*), cow-parsnip, streambank butterweed, and sweet-scented bedstraw (table 6). Lewis' monkey-flower (*Mimulus lewisii*) and brook saxifrage (*Saxifraga arguta*) occupied hydric sites. The dominant shrub species in stratum A (0.0-0.9 m) were alderleaf buckthorn (*Rhamnus alnifolia*), thimbleberry (*Rubus parviflorus*), and willow.

Important bear food items in this vegetation type included mesic herbaceous forbs such as cow-parsnip, dandelion, arrowleaf groundsel, strawberry, western sweet-cicely (*Osmorhiza occidentalis*), and licorice-root (*Ligusticum* spp.) (table 7).

Coefficients of similarity for streamsides varied from 29 to 49 percent when all but ephemeral taxa were included (mean = 37 percent) (table 8). The greatest percent similarity was between the Bigslide and Otter Creek avalanche tracts. When only grizzly bear foods were considered, the average increased to 53 percent (range 28 to 37 percent). The two chutes demonstrating the greatest similarity were Bigslide (east-facing)

Table 4.--Vegetation type importance values and (ranks) for three forage categories (flood plain complex habitat component)[1]

Vegetation type	Forage category: Herbaceous	Modified stem	Fruit
Riparian *Picea*	54 (1)	0.5 (4)	5.0 (4)
Mesic herbaceous meadow	36 (2)	2.0 (2)	25.0 (2)
Populus trichocarpa	10 (3)	2.0 (2)	25.0 (2)
Salix flat	6 (4)	1.0 (3)	9.0 (3)
Xeric graminoid meadow	5 (5)	< .1 (6)	< .1 (6)
Sand bar	5 (5)	5.0 (1)	2.0 (5)
Gravel bar	2 (6)	0.5 (4)	< .1 (6)
Terrestrial *Picea*	1 (7)	0.2 (5)	47.0 (1)

[1]Figures in parentheses indicate ordinal ranking scale.

Table 5.--Acreage and relative percent area (acres/percent area) of each vegetation type in seven sampled avalanche tracts

VT	Chute and aspect: Marshall, south	Babcock, south	Otis, southeast	Bigslide, east	Otter Creek, west	Jumbo, north	Marshall, north
Streamside	25/3	2/1		5/5	3/7	1/8	
Alnus spp.	15/1	7/3		7/8	1/2	1/8	16/89
Mesic herbaceous fan			6/2		8/17		2/11
Xeric herbaceous fan			6/2		21/45		
X. tenax	488/51	95/42	127/39		3/7		
Xeric	433/45	124/54	182/57	80/87	10/22	6/50	
Burn shrubfield[1]						4/34	
Total	961/100	228/100	321/100	92/100	46/100	12/100	18/100

[1]This VT was not found in any other avalanche tract. The upper part of this chute contained a burned *Abies lasiocarpa/Xerophyllum tenax - Vaccinium globulare* habitat type (Pfister and others 1977).

Table 6.--Relative percent cover and occurrence (percent cover/percent occurrence) of dominant taxa in six avalanche chute vegetation types

	Vegetation type					
	Xeric n=114	Xeric herbaceous fan n=26	Xerophyllum tenax n=93	Streamside n=129	Alnus shrubfield n=52	Mesic herbaceous fan n=45
FORBS:						
Balsamorhiza sagittata	3/25					
Achillea millefolium	[1]t/8 2	1/91	t/73			2/38
Sedum stenopetalum	t/60					
Antennaria microphylla	1/49					
Galium boreale		5/25				
Fragaria virginiana		6/78	5/63			
Osmorhiza occidentalis		5/38	2/20		1/15	1/36
Aster spp.		10/75				
Solidago canadensis		5/38				
Xerophyllum tenax			45/82			9/36
Erigeron spp.			5/60			
Senecio triangularis				19/70	/75	15/73
Heracleum lanatum				7/47	8/52	4/40
Senecio pseudaureus				6/59		
Galium triflorum				2/24	2/52	
Taraxacum spp.				2/30		
Veratrum viride					/54	
Thalictrum occidentale			1/35		/50	5/78
Streptopus amplexifolius					1/42	
SHRUBS:						
Amelanchier alnifolia	5/51		1/26			
Rhamnus alnifolia		18/28				
Symphoricarpos albus		5/16				
Vaccinium scoparium			4/21			
Vaccinium globulare			1/11			
Alnus spp. (0.9-2.0 m)					40/89	
Alnus spp. (>2.0 m)				4/15	38/71	
Sorbus spp. (0.9-2.0 m)					3/17	
Salix spp. (0.9-2.0 m)				3/15		
Ribes lacustre						5/22
GRAMINEAE/CYPERACEAE	30/100	21/100	8/60	8/100	/72	26/100
NONVASCULAR COVER	45/100	2/100	20/100	9/100	/100	12/100

[1]t = <0.5 percent cover.

Table 7.--Relative percent cover and occurrence (percent cover/percent occurrence) of major bear food items in avalanche chute vegetation types

	Vegetation type					
Taxa	Streamside	Alnus spp.	Mesic herbaceous fan	Xeric herbaceous fan	X. tenax	Xeric
HERBACEOUS						
Heracleum lanatum	7/47	8/52	4/40	t/9	t/3	
Angelica arguta	3/43	1/10	1/18	t/9	t/5	
Ligusticum canbyi	[1]t/8	1/14				
Osmorhiza occidentalis		1/15	1/36	5/38	2/20	t/8
Taraxacum spp.	2/30					
MODIFIED STEMS						
Aster spp.				10/75	t/4	t/5
Erythronium grandiflorum	t/6				t/12	t/2
Hedysarum occidentale			t/2		1/28	
Lomatium spp.	t/2		t/4		t/5	t/27
FRUITS						
Sorbus scopulina	3/17	1/8	t/2		1/6	t/1
Vaccinium caespitosum		t/2	t/2		4/21	t/3
Vaccinium scoparium		t/2	t/2		4/21	t/3
Ribes spp.	t/22	3/10	5/22			
Amelanchier alnifolia					1/26	5/51

[1]t = <0.5 percent cover.

Figure 5.--Mesic herbaceous fan (A), xeric (B), and Alnus spp. (C) VT's of the avalanche chute complex (Otter Creek).

Figure 6.--An extensive area of the Alnus spp. VT of the avalanche chute complex (near Koessler Lake).

Figure 7.--The Xerophyllum tenax VT of the avalanche chute complex (Otis Creek).

and Babcock (south-facing). Only three of 113 taxa were common to all streamsides: western meadowrue, cow-parsnip, and arrowleaf groundsel.

2. Alnus spp. VT. Shrubfields dominated by mountain alder were found on cool and moist sites in all but the south-facing chutes in Marshall and Otis Creeks. North-facing and east-facing portions of avalanche chutes tended to support the most extensive alder stands. In south-facing chutes, alder shrubfields generally were restricted to streamside areas. The Alnus spp. VT usually occupied a low percent area of the avalanche complexes (table 5).

The dominant shrub over 0.9 m was alder; however, 11 other shrubs did occur in this vegetation type. The most common species included willow, fool's huckleberry (Menziesia ferruginea), black twin-berry, and alderleaf buckthorn. Common herbaceous species included American false hellebore (Veratrum viride), arrowleaf groundsel, and western meadowrue (table 6). Mesic herbaceous bear food items such as cow-parsnip, sharptooth angelica, licorice-root, and western sweet-cicely were also common under the canopies of alder and along the shrub ecotones.

The average of 10 similarity coefficients using all taxa was 37 percent. When only bear foods were evaluated, the coefficient increased to 39 percent. The greatest similarity among chutes was 50 percent (table 8).

3. Mesic herbaceous fan. The lower portions of cool and moist aspect avalanche chutes frequently supported mesic herbaceous and graminoid vegetation. Because of the northerly to northwesterly aspect and/or upper elevational position of these chutes, these fans held snow longer than other chutes and exhibited delayed phenological development. Mesic herbaceous fans were found in the west-facing Otter Creek, southeast-facing Otis Creek, and the north-facing Marshall Creek avalanche chutes.

Arrowleaf groundsel, beargrass (Xerophyllum tenax), western meadowrue, and cow-parsnip were dominant herbs (table 6). Grasses and sedges showed a combined coverage of 19 percent and appeared in all sample plots. Nonvascular ground comprised 9 percent cover. Occasional stems of subalpine fir (Abies lasiocarpa), Douglas-fir, and spruce were present.

Key bear foods were much the same as those mesic herbaceous species found in the streamside and Alnus spp. VT's (table 7).

4. Xeric herbaceous fan. The vegetation of several avalanche fans was greatly influenced by surface and subsurface ephemeral stream runoff. On exceedingly convex and generally warm-aspect fans, combinations of taxa slowly graduated from mesic conditions associated with the streamside toward drier conditions near the edges. One example of this drier fan type was at Bigslide.

Table 8.--Individual and average Jaccard percent similarity coefficients for vegetation types of the avalanche chute habitat component (all but ephemeral taxa/grizzly bear foods only)

Streamside VT (n=129)

	Marshall Cr. S. facing n=31	Bigslide E. facing n=26	Otter Cr. W. facing n=23	Babcock Cr. S. facing n=29	Jumbo Cr. N. facing n=20	Otis Cr. SW. facing	Marshall Cr. N. facing	Averages
Marshall Cr.		38/38	34/61	44/70	33/55	Absent	Absent	37/53
Bigslide			49/47	38/75	29/28			
Otter Cr.				31/63	37/54			
Babcock Cr.					34/41			

Alnus Shrubfield VT (N=52)

	Jumbo Cr. N. facing n=8	Bigslide E. facing n=12	Otter Cr. W. facing n=10	Babcock Cr. S. facing n=12	Marshall Cr. N. facing n=10	Otis Cr. SW. facing	Marshall Cr. S. facing	Averages
Jumbo Cr.		40/21	35/50	36/27	27/33	Absent	Absent	37/32
Bigslide			30/36	41/32	33/19			
Otter Cr.				27/22	48/50			
Babcock Cr.					48/27			

Xerophyllum tenax VT (n=93)

	Babcock Cr. S. facing n=55	Bigslide E. facing n=12	Marshall Cr. S. facing n=20	Otis Cr. SW. facing n=6	Otter Cr. W. facing	Jumbo Cr. N. facing	Marshall Cr. N. facing	Averages
Babcock Cr.		28/38	25/33	25/39	Absent	Absent	Absent	32/36
Bigslide			27/18	50/45				
Marshall Cr.				38/40				

Xeric, warm aspect VT (n=114)

	Marshall Cr. S. facing n=34	Bigslide E. facing n=18	Otter Cr. W. facing n=36	Babcock Cr. S. facing n=20	Otis Cr. SW. facing n=6	Marshall Cr. N. facing	Jumbo Cr. N. facing	Averages
Marshall Cr.		45/60	37/43	38/36	33/45	Absent	Absent	34/39
Bigslide			32/21	31/50	28/20			
Otter Cr.				29/29	35/40			
Babcock Cr.					32/45			

Alderleaf buckthorn was the dominant species at sites of high moisture with cow-parsnip, western meadowrue, sharptooth angelica, western sweet-cicely, and blue stickweed (Hackelia jessicae) present beneath the shrub canopy. Wild strawberry, northern bedstraw (Galium boreale), asters, fleabane, sulfur buckwheat, and sticky purple geranium (Geranium viscosissimum) occupied the drier sites. Snowberry (Symphoricarpos albus) and swamp gooseberry (Ribes lacustre) were dry site shrubs.

5. Xerophyllum tenax VT. Vegetation dominated by beargrass varied greatly in areal extent among avalanche chutes. It occupied as much as 50 percent of Marshall Creek's south-facing chute to only 11 to 12 percent of the Otter and Babcock avalanche complexes (table 5). At the Marshall and Otis Creek locations, this vegetation type dominated much of the upper undulating portions as well as the low fanlike areas at the bottoms of the chutes. The Xerophyllum tenax VT was found in all but the north-facing Marshall Creek and west-facing Otter Creek avalanche chutes. Beargrass showed the greatest herbaceous cover value with strawberry, fleabane, western sweet-cicely, and western meadowrue also exhibiting relatively high coverages. Grouse whortleberry (Vaccinium scoparium) was the dominant shrub under 0.9 m. Cover of globe huckleberry (Vaccinium globulare) was the greatest in burned areas. Nonvascular ground had a cover value of 20 percent. Combined, grasses and sedges showed 8 percent cover.

Certain upper-elevation portions of sampled avalanches had been subjected to ground fires within the last 50 years (Babcock and Jumbo Creeks). The most obvious influence of fire on these sites was an increase in shrub presence and cover values. For example, the upper elevation Xerophyllum tenax VT of the Babcock Creek chute (burned 1934) showed twice the number of shrub taxa compared to other similar sites. Due to fire influences, similarity coefficients were low (table 8). Principal bear foods of the Xerophyllum tenax VT included the berry-producing shrub species (particularly where fires had occurred) and grasses and sedges. Other species included such forbs as yarrow (Achillea millefolium), wild strawberry, Indian paintbrush (Castilleja spp.), valerian (Valeriana spp.), and modified stems such as western hedysarum.

Similarity coefficients among vegetation types sampled from four avalanche chutes ranged from 28 to 45 percent when ephemeral taxa were excluded. When considering bear food items only, the similarity coefficients ranged from 21 to 60 percent similarity.

6. Xeric VT. The xeric VT occurred on steep, thin, and well-drained soils in all but the north-facing avalanche chutes. This vegetation type frequently occupied linear bands along the south-facing aspects of the concave avalanche chutes. In the more expansive chutes, the xeric VT was intermixed with the Xerophyllum tenax VT. Where this vegetation type occurred, it occupied more than 40 percent of the avalanche chute (table 5).

Dominant species in the xeric VT included arrowleaf balsamroot (Balsamorhiza sagittata), yarrow, and wormleaf stonecrop. Among shrubs, serviceberry (Amelanchier alnifolia) showed the greatest cover. Grasses, principally Idaho fescue, bluebunch wheatgrass (Agropyron spicatum), showy oniongrass (Melica spectabilis), and sedges had a combined cover of 25 percent. Nonvascular ground cover constituted 32 percent. Except for grasses and sedges, bear food items were not particularly common in this vegetation type. Most notable were modified stems such as wild onion and several species of biscuit-root (Lomatium spp.).

Similarity coefficients derived from five sampled xeric VT's averaged 35 percent for all but ephemeral taxa. When only grizzly bear foods were considered, the similarity increased to 39 percent (table 8).

Ranking of Vegetation Type Importance Values by Forage Category

Herbaceous Forage Category.--For the herbaceous foraging strategy, the highest ranking vegetation type was the Alnus spp. VT (IV = 61) followed by the mesic herbaceous fan, streamside, and xeric herbaceous fan (table 9). The Xerophyllum tenax VT was ranked fourth (IV = 27), and the xeric VT ranked lowest (table 9).

Modified Stems Forage Category.--Importance values for modified stems were relatively low (table 9). The X. tenax VT ranked the highest (IV = 5) due to the occurrence of western hedysarum, milk-vetch (Astragulus spp.), and glacier-lily (Erythronium spp.). The xeric VT ranked second highest and contained digging food items such as wild onion, milk-vetch, fern-leaved and Sandberg's biscuit-root (Lomatium dissectum and L. sandbergii), and glacier-lily.

Fruit Forage Category.--Most avalanche vegetation types exhibited low fall foraging season values because of a general lack of berry-producing shrubs in the nontimbered portions of the tracts. The xeric herbaceous fan VT scored the highest value for the fall foraging season (IV = 26) due to the presence of shrub species such as serviceberry and alderleaf buckthorn.

DISCUSSION

To date, very little information on grizzly bear food habits or habitat use exists for the Bob Marshall Wilderness. Therefore, it was assumed, for this investigation, that grizzly bear food habits and habitat selection in the Bob Marshall Wilderness would be similar to those of other grizzly bears studied in northwest Montana. It also was assumed that grizzly bears would select food resources at the vegetation type level rather than at the component level. This was

Table 9.--Vegetation type importance values of six avalanche tract vegetation types for three foraging strategies[1]

Vegetation type	Forage category		
	Herbaceous	Modified stem	Fruit
Alnus spp.	61 (1)	< 0.1 (4)	3 (5)
Mesic fan	40 (2)	< 0.1 (4)	5 (4)
Streamside	37 (3)	0.1 (3)	3 (5)
Xeric fan	32 (4)	< 0.1 (4)	26 (1)
X. tenax	27 (5)	3.0 (1)	9 (2)
Xeric	3 (6)	1.0 (2)	8 (3)

[1]Figures in parentheses indicate ordinal ranking scale.

corroborated by Stelmock (1981), who stated that:

> [Grizzly bear] habitat use during summer was mainly confined to very specific vegetation types which provided dense cover of favored plant foods. Habitat use patterns closely followed the seasonal variations in quantity and quality of important foods.

This investigation focused on assessing the relative foraging importance to grizzly bears of various vegetation types within both avalanche chutes and flood plains. Results indicate that both flood plains and avalanche tracts are composed of a variety of distinguishable vegetation types within which bear food items varied in composition and abundance. In addition to the forage quality of specific vegetation types, it is important to consider the distribution and juxtaposition of these vegetation types as well as their areal extent.

The more mesic vegetation types within avalanche chutes and flood plains clearly provided an abundance of mesic herbaceous bear foods such as cow-parsnip, sawtooth angelica, western sweet-cicely, and others. Often, these vegetation types occupied the least area. For example, in avalanche tracts, the Alnus spp. VT ranked highest for the herbaceous category, but occupied the least area of most chutes sampled.

In avalanche chute VT's, the xeric fan exhibited the highest IV for the fruit category, primarily because of the abundance of alderleaf buckthorn found in the stream area of the fan. In general, fruit-bearing shrubs were not abundant in any of the avalanche vegetation types sampled except where the types had burned (Babcock and Jumbo). Even in the burns, the abundance of fruit-bearing shrubs was not extensive; however, fruit-bearing shrubs such as globe huckleberry were highly abundant in the timbered stringers located within many avalanche tracts and along the timbered edges. These areas were not sampled in the manner of the avalanche chutes and were considered part of the forest habitat types. Results of sampling forested types are reported elsewhere (Mace, this volume). The highest ranking area for fruit-producing shrubs in the flood plain complex was on the benches above the river channel. The diversity of shrub taxa sought by grizzly bears was less on the benches as compared to the riparian zone. However, the high importance value of these areas was attributed to a few, highly favored fruit-bearing shrubs such as buffaloberry.

Vegetation types in both the avalanche tracts and flood plains generated relatively low importance values for the modified stem category. It appears that because of the small above-ground size and the ephemeral nature of digging food items, the sampling methods used in this study were not sensitive to this food category. Even other components such as slab rock and alpine meadows, which contain a variety of digging foods, yielded importance values less than 5 (Mace, this volume). The consistency of these habitat descriptions within the study area was evaluated using the Jaccard Similarity coefficient (Jaccard 1912). Results of the similarity coefficients indicated that seasonal forage values should be assessed from many areas and not from a single avalanche tract or portion of a flood plain. Similarity coefficients, using a conservative number of grizzly bear food items, were rarely over 50 percent for each avalanche tract vegetation type sampled from different areas. If one were to only intensively sample one avalanche tract, the descriptions would be less than 50 percent similar in bear food composition in comparison to other chutes in the area.

To look at the extent to which avalanche vegetative descriptions could be extrapolated, avalanche tracts in the northern end of the Bob Marshall wilderness were inspected. Comparisons indicated subtle differences in vegetative compositions and occurrences of certain vegetation types. For example, south-facing avalanche tracts of Trickle and Cannon Creeks in the northern Bob Marshall contained mesic herbaceous meadows which were not found in south-facing avalanches in the southern study area. In addition, plant indicators of relatively moist habitats such as pachistima (Pachistima myrsinites) and queen's cup were observed much more often in the northern Bob Marshall than in the southern study area. Finally, it was noted that the north-facing

avalanche tracts were more abundant and extensive in the northern wilderness drainages than in the southern ones. Based on these observations, extrapolation of vegetation descriptions and values beyond the study area should be done with caution.

REFERENCES

Allen, H. L. Floodplain plant communities of the North Fork Flathead River, Montana. Research Management Rep. No. 1. West Glacier, MT: Glacier National Park; 1980.

Aune, K.; Stivers, T. Rocky Mountain Front grizzly bear monitoring and investigation. 1982. Unpublished report on file at: Montana Department of Fish, Wildlife and Parks, Helena, MT. 143 p.

Aune, K.; Stivers, T.; Madel, M. Rocky Mountain Front grizzly bear monitoring and investigation. 1984. Unpublished report on file at Montana Department of Fish, Wildlife and Parks, Helena, MT. 239 p.

Craighead, J.; Sumner, J.; Scaggs, G. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Monogr. 1. Missoula, MT: University of Montana, Wildlife-Wildlands Institute; 1982. 279 p.

Daubenmire, R. Structure and ecology of coniferous forests of the northern Rocky Mountains. In: Taber, R., ed. Coniferous forests of the northern Rocky Mountains. Missoula, MT: University of Montana, Center for Natural Resources; 1969: 25-41.

Hitchcock, C.; Cronquist, A. Flora of the Pacific Northwest. Seattle, WA: University of Washington Press; 1973. 730 p.

Jaccard, P. The distribution of the flora of the alpine zone. New Phytol. 11: 37-50; 1912.

Johnson, T. W. An analysis of pack and saddle stock grazing areas in the Bob Marshall Wilderness Area, Montana. Bozeman, MT: Montana State University; 1982. 85 p. M.S. thesis.

McLellan, B. Akamina-Kishinena grizzly project progress report, year 3. 1982. Unpublished report on file at: British Columbia Fish and Wildlife Branch; Cranbrook, BC, Canada.

Mace, R. D.; Jonkel, C. Regional food habits of the grizzly bear in Montana. Paper delivered to the International Conference on Bear Research and Management, Grand Canyon, AZ, 1983 February 18-22.

Mace, R. D.; Jonkel, C. Identification and evaluation of grizzly bear habitat in the Bob Marshall Wilderness Area, Montana. Missoula, MT: University of Montana; 1984. 176 p. M.S. thesis.

Mealey, S.; Jonkel, C.; Demarchi, R. Habitat criteria for grizzly bear management. In: Peterie, T., ed. Thirteenth Congress of Game Biologists; 1977 March 11-15; Atlanta, GA. 1977: 276-289.

Mueggler, W. F.; Stewart, W. L. Grassland and shrubland habitat types of western Montana. General Technical Report INT-66. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 154 p.

Nie, N.; Hull, C.; Steinbrenner, K.; Bent, D. Statistical package for the social sciences. New York: McGraw-Hill; 1975. 675 p.

Pfister, R.; Kovalchik, B.; Arno, S.; Presby, R. Forest habitat types of Montana. General Technical Report INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Pfister, R.; Batchelor, F. F. Montana riparian vegetation types. Western Wildlands. 9(4): 19-23; 1984.

Russell, R. H.; Nolan J. W.; Woody, N. A.; Anderson, G. A study of grizzly bear in Banff National Park, 1975-78. 1979. Final report prepared for Parks Canada by Canadian Wildlife Services, Edmonton, AB. 136 p.

Singer, F. J. Seasonal concentrations of grizzly bears, North Fork of the Flathead River, Montana. Canadian Field-Nat. 2(3): 283-286; 1978.

Stelmock, B. S. Seasonal activities and habitat use patterns of brown bears in Denali National Park-1980. Fairbanks, AK: University of Alaska; 1981. 118 p. M.S. thesis.

Sumner, J.; Craighead, J. Grizzly bear habitat survey in the Scapegoat Wilderness, Montana. Missoula, MT: University of Montana, Montana Cooperative Wildlife Research Unit; 1973. 49 p.

U.S. Department of Agriculture. Valley bottomland inventories with management implications: working draft. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region; 1978. 14 p. Mimeo.

Zager, P. The influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Missoula, MT: University of Montana; 1980. 131 p.

A COMMON SENSE APPROACH TO GRIZZLY BEAR HABITAT EVALUATION

Matthew M. Reid and Steven D. Gehman

ABSTRACT: The common sense approach to evaluating grizzly bear habitat includes three main efforts: (1) collecting and mapping of all known information pertaining to grizzly bear use of an area; (2) on-the-ground reconnaissance and resource sampling (including habitat sampling and mapping, ungulate use surveys, and grizzly bear use surveys); and (3) analysis of data. Ecological and philosophical considerations related to the approach are discussed. Critiques of the Forest Service approach to evaluating grizzly bear habitat in the Clark's Fork Corridor (Shoshone National Forest) and the Mount Hebgen area (Gallatin National Forest) are provided. Special attention is given to Forest Service oversight of critical components of the evaluation process and to the implications of such oversight. The purpose is not to espouse a new methodology, but to remind resource managers that appropriate existing methodologies are frequently overlooked, and that the common sense approach can yield valuable management information if properly conducted. A case study (by Reid Environmental Services) of the proposed evaluation approach to grizzly bear habitat in the Northern Yellowstone Rim area is reviewed. Specific procedures and findings are presented, as are conclusions regarding the applicability of the findings to management of grizzly bear habitat in the Greater Yellowstone Ecosystem. Suggestions for future grizzly bear research efforts in the Greater Yellowstone Ecosystem are presented.

INTRODUCTION

Current delineations of grizzly bear management situations (USDA and USDI 1979) do not accurately reflect grizzly bear use of habitat in many portions of the Greater Yellowstone Ecosystem (GYE). Although the guidelines were intended to define management situations ecologically, many situation boundaries actually reflect political, social, and economic concerns (Hawkes 1976). The purposes of this paper are to review a common sense approach to evaluating grizzly bear habitat in the GYE and to illustrate the applicability and effectiveness of such an approach. We present our methodology and examples of our work in three areas of the Gallatin and Shoshone National Forests, where we determined that delineations of grizzly bear management situations did not reflect grizzly bear use.

The common sense approach to evaluating grizzly bear habitat consists of three main categories of effort: (1) collection and mapping of all known information pertaining to grizzly bear use of an area, (2) on-the-ground reconnaissance and resource sampling, and (3) data analysis.

Collection of pertinent information should include reviews of published literature, agency reports and data, and existing habitat maps and aerial photographs, as well as interviews with agency personnel, researchers, landowners, residents, and users of the area (outfitters, sportsmen, recreationists). Information that should be recorded includes dates, locations, and details of grizzly bear activity in the area and details of habitat alterations (fire, agriculture, logging, development) that have occurred in the area. The product of this phase of work should be a series of map overlays, showing the locations of grizzly bear activity and relevant habitat information.

Habitat sampling and mapping and grizzly bear and ungulate use surveys are critical components that should be conducted during the field work phase of the habitat evaluation process. Appropriate methodologies have been developed for sampling and mapping grizzly bear habitat components in the northern ecosystem (Christensen 1979; Mealey 1977; Mealey and others 1977) and in the Yellowstone Ecosystem (Puchlerz and others 1984). Methods of Puchlerz and others (1984) require determinations of habitat types (Pfister and others 1977), cover types, and nonforest components as the basis for delineating grizzly bear habitat components. We used these methods extensively during our 1984 field season and found them to be appropriate for describing habitat in the northern Yellowstone area. Widespread use of existing methodologies by researchers and resource managers will facilitate uniform documentation, interpretation, and comparison of habitat information.

Thorough surveys of the study area should be conducted during all seasons to document grizzly bear use. Field crews should systematically search for and record observations of bear tracks, scats, day beds, feed sites, and dens. Samples of bear hair should be collected from vegetation, logs, rocks, trails, day beds, and other features for species determinations to be made by a qualified expert. Whenever possible, bear scats should be collected and analyzed to further our knowledge of bear food habits.

If ungulates have been shown to be an important food source for grizzlies, as is the case in the

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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Yellowstone Ecosystem (Knight and others 1980), then surveys of ungulate use patterns should be conducted in conjunction with habitat sampling and grizzly bear use surveys. Efforts should include documentation of species and numbers of ungulates observed, availability of ungulate carrion, and seasonal use patterns of ungulates (including general ranges, and concentrated use areas such as elk calving areas and winter and spring transition ranges). Censuses conducted from roads and transects through ungulate ranges are effective means of obtaining ungulate use data. Whenever possible, results of aerial surveys conducted by State and Federal agencies should be obtained to supplement data.

When planning field activities, factors such as timing of efforts, level of effort, and qualifications of personnel should be carefully considered. Timing of field efforts can seriously affect habitat sampling, grizzly bear activity surveys, and ungulate use surveys. Habitat sampling should be coordinated with the area's plant phenology to ensure that indicator species are present. Grizzly bear use surveys should be conducted during all seasons when bears are active. Special searches should be made to locate den sites, evidence of predenning and postdenning activity, and carcass feed sites. Surveys of ungulate use should be conducted year round; however, special attention should be given to early spring and birthing periods when grizzlies are most likely to prey upon vulnerable ungulates. It is impossible to establish specific guidelines for appropriate levels of field activities; however, effort should be expended until experienced personnel feel that samples representative of the area have been obtained during all critical periods of the year. Finally, it is important to have trained personnel conducting the field sampling and surveys. All of these factors contribute to the accuracy and applicability of results obtained from field work.

Data analysis should include compilation of qualitative and quantitative descriptions of habitat and associated use by grizzly bears. Habitat components should be mapped and assigned importance values. Grizzly bear and ungulate use data should be mapped on overlays to aid in visualizing habitat-animal interactions. Several guidelines should be kept in mind when examining results from the habitat evaluation process:

1. Although it may be desirable or necessary to divide an area into smaller units for evaluation, always maintain a broad perspective of grizzly bear requirements and of options available to grizzlies for achieving those requirements; that is, keep in mind the biological characteristics of the animal and ecological relationships that govern the animal's behavior (U.S. Government 1983; Mealey 1977).

2. Consider cumulative impacts to grizzly bears on an ecosystem-wide basis; when considered as small, individual pieces of habitat, few areas are absolutely critical to the survival of grizzly bears in a particular ecosystem; however, the juxtaposition of habitat units and knowledge of the cumulative characteristics of and pressures on those units play a significant role in the value or importance of any one unit.

3. Acknowledge the variable nature of biological and ecological relationships; results from one season or one area are only samples.

FOREST SERVICE EVALUATIONS

Mount Hebgen Area.--Our first example of grizzly bear habitat evaluation in the Greater Yellowstone Ecosystem comes from the Mount Hebgen area of the Gallatin National Forest in southwestern Montana. In 1973, Ski Yellowstone, Inc., applied for a special use permit to develop a winter sports complex at Mount Hebgen. The Ski Yellowstone Corporation then funded a wildlife study in the Mount Hebgen area during spring and summer of 1973 (Haglund 1973). The study consisted of two flights over the study area and an undocumented amount of on-the-ground reconnaissance work. The objective of the study apparently was to evaluate potential impacts of development on wildlife in the Mount Hebgen area. The project report dealt mainly with big game animals (elk and moose) and included one short paragraph about grizzly bears (Haglund 1973). Grizzly bear activity was documented in three drainages near the proposed development site, but not on the primary study area.

The Forest Service, U.S. Department of Agriculture, then issued the special use permit for the Ski Yellowstone development. In response to public opposition to this decision and to concerns about potential impacts to wildlife, particularly grizzly bears, the Ski Yellowstone Corporation funded a second wildlife study near the development site. This study was conducted by Mealey (1976) during late spring and early summer, 1976, and was oriented toward evaluating grizzly bear habitat quality in the Mount Hebgen area. Based on the area's low potential for producing grizzly bear food, Mealey (1976) concluded that the area was low-quality grizzly habitat. Other important factors related to grizzly bear ecology were not considered in this study (Mealey 1977).

In 1977, the Forest Service completed an Environmental Impact Statement (EIS) for development in the Mount Hebgen area. The EIS indicated the preferred alternative was to construct the proposed Ski Yellowstone development. In the EIS, all data concerning potential impacts to wildlife came from the previously mentioned studies of Haglund (1973) and Mealey (1976). Included in the EIS was a Fish and Wildlife Service, U.S. Department of the Interior, biological opinion of "no jeopardy" to the Yellowstone grizzly bear population.

For the next several years, public comments and debate were heard regarding the EIS and the proposed development. Meanwhile, in 1979, the "Guidelines for Management Involving Grizzly Bears in the Greater Yellowstone Area" were published

(USDA and USDI 1979), and efforts to classify grizzly bear habitat according to management situations (MS) began. Although the entire Mount Hebgen area was proposed as critical grizzly bear habitat by the Fish and Wildlife Service in 1976 (USDI 1976), the Forest Service classified the site of the proposed Ski Yellowstone development as MS 2 habitat and land immediately adjacent to the site as MS 1 (USDA and USDI 1979).

In August, 1982, the Forest Service granted a special use permit for the development of the Mount Hebgen area by the Ski Yellowstone Corporation. Concern for grizzly bears and other wildlife resurfaced, and in 1983 several conservation groups asked the Fish and Wildlife Service to review data and reconsider the 1977 biological opinion of "no jeopardy" to grizzly bears. The Fish and Wildlife Service complied with this request and in 1984 reaffirmed the "no jeopardy" opinion (Brewster 1984).

We believe that the Forest Service and Fish and Wildlife Service overlooked several significant factors when they evaluated the Mount Hebgen area as grizzly bear habitat. First, they made little effort to obtain and use information regarding grizzly bear use of the area from residents and users of the area, and from researchers from other agencies. Local residents and users of the area should have been interviewed throughout the evaluation process, and their responses should have been documented in the EIS. Similarly, pertinent information should have been collected from the Interagency Grizzly Bear Study Team (IGBST). The IGBST had been recording grizzly bear sightings in the Mount Hebgen area since 1973 and had been monitoring locations of radio-collared grizzlies in the area since 1975 (Knight and Blanchard 1984); none of the IGBST data appeared in the EIS. The significance of this omission was especially apparent in the 1984 review of data conducted by the Fish and Wildlife Service. By that time, the IGBST had been recording sightings of grizzlies for 10 years and radio-locations of grizzlies for 8 years, and had accumulated a significant amount of data regarding grizzly bear use of the Mount Hebgen area. For example, between 1973 and 1983, 84 sightings of single grizzlies and 15 sightings of females with young were made within 10 miles of Mount Hebgen; between 1975 and 1983, seven radio-collared grizzlies used the Mount Hebgen area (Knight and Blanchard 1984). The distributions of documented sightings and radio-locations of grizzlies (fig. 1) indicate that Mount Hebgen and the surrounding area were heavily used by grizzlies between 1973 and 1983 (Knight and Blanchard 1985) and that management situation delineations did not reflect that use.

During the EIS review process, representatives of the Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the Montana Department of Fish, Wildlife, and Parks all expressed concerns regarding the welfare of grizzly bears and their habitat (USDA 1977); however, none of these concerns was adequately addressed by the Forest Service before the special use permit was granted.

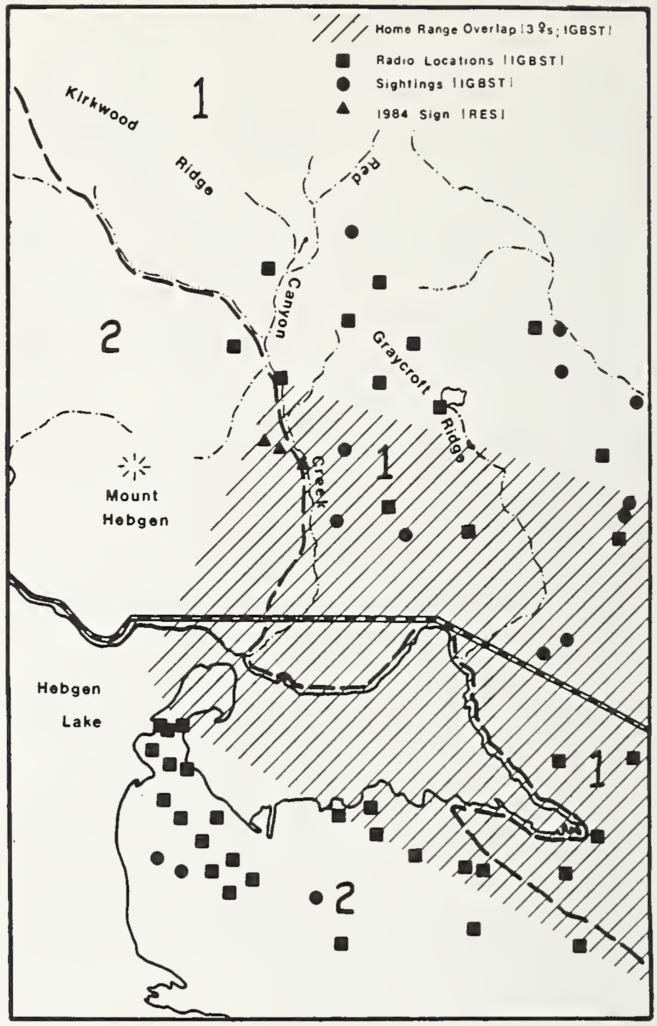

Figure 1.--Distributions of sightings and radio-locations of grizzly bears, 1973-83, in management situations in the Hebgen area, Gallatin National Forest.

A second major problem was inadequate field work and incomplete examination of critical grizzly bear components. The studies of Haglund (1973) and Mealey (1976) were conducted in late spring and early summer, and neither investigator made an intensive search for evidence of grizzly bear activity. Although Haglund (1973) documented big game distributions and Mealey (1976) studied grizzly bear food production, neither investigator examined the potential for ungulates as a major grizzly bear food source in the Hebgen area. Intensive surveys of grizzly bear and ungulate activity should be conducted throughout the portion of the year that grizzly bears are active (approximately April through October).

We visited Mount Hebgen in June 1984 while participating in a Forest Service grizzly bear habitat mapping workshop. During the approximately 4 hours that we spent mapping habitat components on Mount Hebgen, we discovered two

sites where grizzlies had recently fed upon elk, three grizzly bear day beds, three bear scats, and two sets of grizzly bear tracks (Reid 1984). Because of the potential impacts of a project like Ski Yellowstone, these kinds of evidence should have been gathered and documented by Forest Service personnel each year since the development proposal was made.

We feel that Forest Service and Fish and Wildlife Service personnel have not demonstrated an adequate ecological perspective of grizzly bear needs in the Yellowstone Ecosystem. They isolated and examined the Mount Hebgen area as an island of habitat and paid little attention to habitat quality, geographical position, or human pressures in surrounding areas; nor did they relate that information to grizzly bear ecology and the Mount Hebgen management problem. Knight and Blanchard (1984) expressed similar concerns, noting that although food and cover on the Mount Hebgen site may not be critical to the Yellowstone grizzly bear population, the proposed development has the potential to become a population sink that could have serious negative impacts upon grizzlies.

In the summer of 1984 the Forest Service initiated its newly formed Cumulative Effects Analysis process (Puchlerz and others 1984) in the Mount Hebgen area. The results of such analysis, if accompanied by more intensive surveys of grizzly bear and ungulate activity and a broader perspective of the Yellowstone grizzly bear situation, could provide a more realistic evaluation of grizzly bear habitat in the Hebgen area and a more appropriate delineation of management situations. It is our hope that the Forest Service will proceed along these lines.

Clark's River Corridor.--Our second example of inadequate evaluation of grizzly bear habitat by the Forest Service comes from the Clark's Fork River Corridor in the Shoshone National Forest (northwestern Wyoming).

In 1978, the Forest Service began to study the potential for a snowmobile route from Cooke City, MT, to Crandall Junction, WY, through the Clark's Fork Corridor. The proposed route would use existing cleared trailways but would cross grizzly bear habitat. When grizzly bear management situations were delineated in this area in 1979, the Forest Service classified the Clark's Fork Corridor as MS 2 and MS 3, although area surrounding the corridor on three sides was classified as MS 1 (USDA and USDI 1979; fig. 2). Classification of the corridor was ecologically unfounded and was instead based upon land ownership and political concerns (KRA Natural Resource Consultants 1983).

In 1982, the Forest Service released its final Environmental Assessment for the proposed project, reporting that the project would have little environmental impact. The Forest Service concluded that there would be no effect on threatened or endangered species and consequently did not consult with the U.S. Fish and Wildlife Service regarding the project. The Forest Service evaluation of grizzly bear habitat along the proposed trail route was based solely on importance values (Mealey 1977) for existing vegetative types (USDA 1982).

In October 1983, a private landowner hired Kopec-Reid Associates (now Reid Environmental Services) to investigate and document grizzly bear use of the Clark's Fork Corridor. KRA based its investigation on the common sense approach that we have outlined, and obtained data that refuted Forest Service conclusions about the area's value to grizzly bears (KRA Natural Resource Consultants 1983). First, KRA used IGBST data to show that home ranges of 12 radio-collared grizzlies included portions of the Clark's Fork Corridor (fig. 2) and that the study bears used the corridor primarily during spring and fall. KRA sampled habitat along the corridor and documented the occurrence of high-value grizzly bear habitat components. An ungulate survey revealed significant use of the corridor by moose, and a survey of grizzly bear activity indicated that grizzlies were present and preyed upon moose during fall, 1983. Study results also indicated that suitable grizzly bear denning habitat was available adjacent to the corridor.

The following example illustrates the inadequacy of the Forest Service habitat evaluation process. The Forest Service assessment showed the absolute and relative weightings of grizzly use of One Mile Creek, along the Clark's Fork Corridor, to be zero (USDA n.d., field notes by B. Haflich); that is, One Mile Creek had no value to grizzly bears. KRA surveys revealed that moose use One Mile Creek during spring and fall and that grizzlies had fed on a moose carcass in the One Mile Creek drainage. The point of this example is that use of habitat importance values to determine grizzly bear habitat quality should be accompanied by review of known data and intensive on-the-ground ungulate and grizzly bear use surveys during appropriate seasons.

West Gardiner Unit.--Our third and most recent example of grizzly bear habitat evaluation is from the West Gardiner unit of the Gallatin National Forest. In 1977, the Forest Service began to explore the possibility of increasing public access into the Mol Heron Creek drainage (USDA 1977), which flows from the northern boundary of Yellowstone National Park into the Yellowstone River. By 1983 the Forest Service had expanded its intentions, deciding that increased access into five major drainages of the West Gardiner unit would be desirable. In September 1984, the Forest Service released an Environmental Assessment (EA) of the proposed access program (USDA 1984). The EA and accompanying Biological Evaluation were extremely vague and lacked specific details regarding proposed actions and environmental impacts of those actions. Although all areas under consideration were within Occupied Grizzly Habitat (USDA and USDI 1979), few data were presented relating to potential or actual grizzly bear use of those areas or to potential impacts to grizzly bears. The EA included a listing of IGBST-instrumented bears that used the

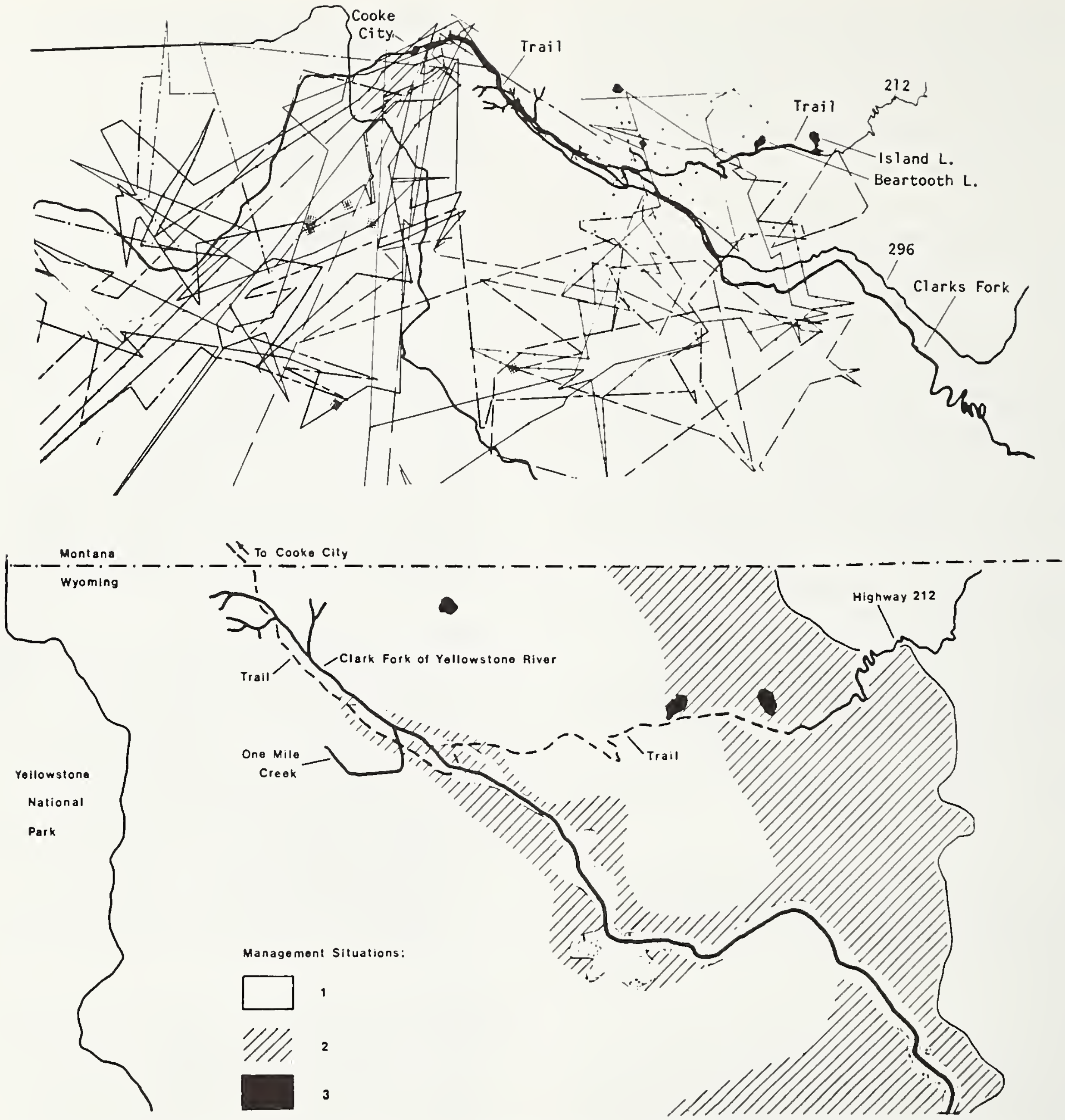

Figure 2.--Life ranges of 12 radio-instrumented grizzly bears (top), and delineations of management situations (bottom) in the Clark's Fork Corridor, Shoshone National Forest.

study area and some general information regarding cub production and denning by grizzlies in the Yellowstone Ecosystem (USDA 1984). No analyses of previously collected grizzly bear use data were presented, and no field work was conducted as part of the Forest Service evaluation process.

Out of concern for their land, their lifestyles, and the natural resources of the area, landowners, residents, and users of the West Gardiner unit formed a group (the Northern Yellowstone Rim Alliance) and hired Reid Environmental Services to investigate natural resource issues related to the Forest Service proposal. Preliminary planning and collection of background information began in January 1984, and field work began in early May. The majority of our work centered around evaluation of the area as grizzly bear habitat.

We examined all IGBST data pertaining to the West Gardiner unit and constructed maps of radio-locations, recorded sightings, and life ranges of grizzly bears. This information alone demonstrated significant use of the area by grizzlies between 1974 and 1984.

Our own field work consisted of (1) interviews with residents and users of the area, (2) extensive surveys of grizzly bear and ungulate activity in all drainages included in the access proposal, (3) intensive sampling and mapping of grizzly bear habitat components in selected portions of the area, and (4) reconnaissance of potential denning habitat.

During this process we collected and documented locations of bear scats and samples of bear hair, located ungulate carcasses fed upon by grizzlies, located numerous grizzly bear day beds and several grizzly bear dens, made overlays of grizzly bear habitat components in the selected areas, documented sightings of grizzly bears by residents and users of the area, and documented seasonal habitat use patterns of ungulates.

Overall, we documented relatively high use of the area by grizzlies during spring, summer, and fall, 1984. Our data plus those of the IGBST indicate that grizzly bear use of the area is substantial and that management situation delineations do not accurately reflect grizzly bear use of the West Gardiner unit. Again, we believe that a common sense approach has led to a more realistic evaluation of grizzly bear habitat than have Forest Service procedures.

REDEFINING MANAGEMENT SITUATIONS

Ultimately, we believe that a more conservative view of critical grizzly bear habitat, such as the delineation presented by Craighead (1980), is needed in the Yellowstone Ecosystem until the grizzly bear population recovers. However, we realize that such a change may be unrealistic under current management constraints. If the current system is to be followed, we feel that grizzly bear management situations for the Yellowstone Ecosystem need to be redefined, and in many instances redelineated, to more accurately reflect grizzly bear habitat use and needs. Many MS boundaries reflect political, social, or economic convenience and do not correspond to the ecologically based definitions of management situations. We propose the following redefinition of management situations, based on ecological and management considerations:

Management Situation 1: All public land within occupied grizzly habitat (USDA and USDI 1979); grizzly bear recovery is the main priority.

Management Situation 2: The fringe of public lands outside of occupied grizzly habitat, representing an ecological buffer zone to MS 1; these areas are used by grizzlies for various reasons but do not represent population centers.

Management Situation 3: Private land within occupied grizzly habitat and the ecological fringe surrounding it; private activities in these areas could jeopardize the grizzly population; agency jurisdiction is limited.

Management Situation 4: Private land outside of occupied grizzly habitat and the ecological fringe surrounding it; activities on these lands are not likely to jeopardize the grizzly population; agency jurisdiction is limited.

Management Situation 5: Public land outside of occupied grizzly habitat and the ecological fringe surrounding it; lands occasionally used by grizzlies but activities not likely to jeopardize the grizzly population; management issues should be decided on a case-by-case basis.

If management situations are redefined in this manner, we believe they will more realistically represent grizzly bear needs and jurisdictional concerns of management agencies. On the basis of our evaluation we suggest reevaluating grizzly bear habitat in 11 areas of the Yellowstone Ecosystem (fig. 3).

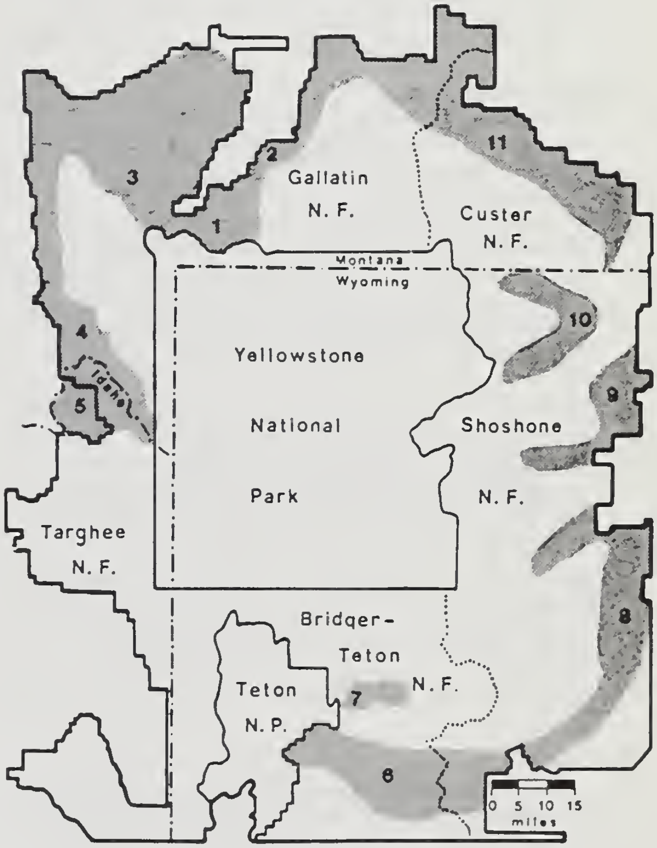

Figure 3.--Locations of areas within the Yellowstone ecosystem that need reevaluation of grizzly bear habitat: 1, West Gardiner unit (Gallatin National Forest); 2, West front of north Absaroka Range (Gallatin National Forest); 3, Southern Gallatin Range (Gallatin National Forest); 4, Hebgen Lake-West Yellowstone area (Gallatin National Forest); 5, Henry's Lake-Island Park area (Targhee National Forest); 6, Gros Ventre River (Bridger-Teton National Forest); 7, Area east of Moran Junction (Bridger-Teton National Forest); 8, Shoshone River System (Shoshone National Forest); 9, Sunlight Creek-Crandall area (Shoshone National Forest); 10, Clark's Fork of the Yellowstone River (Shoshone National Forest); 11, Boulder-Stillwater River Systems (Gallatin National Forest, Custer National Forest).

REFERENCES

Brewster, Wayne G. [Memo to Tom Coston, Regional Forester]. 1984 January 4. Located at: U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT.

Christensen, A. G. Cumulative effects analysis process. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1979. 11 p.

Craighead, John J. A proposed delineation of critical grizzly bear habitat in the Yellowstone region. Bear Biology Association, Monograph Series No. 1; 1980. 20 p.

Haglund, Brent M. Wildlife ecology. In: Montagne, J., ed. Ski Yellowstone environmental study. 1973. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Gallatin National Forest, Bozeman, MT.

Hawkes, Lewis. [Internal memo to Forest Supervisor of Shoshone National Forest]. 1976 November 16. Located at: U.S. Department of Agriculture, Forest Service, Shoshone National Forest, Cody, WY.

Knight, R. R.; Blanchard, B. M. 1985. Unpublished data on file at: Interagency Grizzly Bear Study Team, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Bozeman, MT.

Knight, R. R.; Blanchard, B. M. Potential effects of the Ski Yellowstone development on grizzly bears. 1984. Unpublished paper on file at: Interagency Grizzly Bear Study Team, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Bozeman, MT. 5 p.

Knight, R. R.; Blanchard, B. M.; Kendall, K. C.; Oldenburg, L. F. Yellowstone grizzly bear investigations: annual report of the Interagency Study Team, 1979. Bozeman, MT: U.S. Department of the Interior, Park Service; 1979. 91 p.

KRA Natural Resource Consultants. Assessment of grizzly bear utilization and habitat quality in the Clark's Fork Snowmobile Trail Corridor. 1983. Unpublished report on file at: Reid Environmental Services, Bozeman, MT. 76 p.

Mealey, Stephen P. A survey for grizzly bear habitat on the Mount Hebgen winter sports special use application site and adjacent areas. 1976. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Gallatin National Forest, Bozeman, MT. 22 p.

Mealey, Stephen P. Method for determining grizzly bear habitat quality and estimating consequences of impacts on grizzly habitat quality. 1977. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT. 35 p.

Mealey, S. P.; Jonkel, C. J.; Demarchi, R. Habitat criteria for grizzly bear management. Proceedings, International Congress of Game Biologists. 13: 276-289; 1977.

Pfister, R. D.; Kovalchik, B. L.; Arno, S. F.; Presby, R. C. Forest habitat types of Montana. General Technical Report INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1972. 174 p.

Puchlerz, T.; Despain, D.; Mattson, D. Grizzly bear habitat component mapping handbook for the Yellowstone ecosystem. Bozeman, MT: U.S. Department of the Interior, National Park Service; U.S. Department of Agriculture, Forest Service; 1984. 31 p.

Reid, M. M. [Letter to Wayne Brewster]. 1984 June 19. Located at: Reid Environmental Services, Bozeman, MT.

U.S. Department of Agriculture, Forest Service. [Field notes by Bruce Haflich]. n.d. Unpublished data on file at: U.S. Department of Agriculture, Forest Service, Shoshone National Forest, Clarks Fork Ranger District, Powell, WY.

U.S. Department of Agriculture, Forest Service. Gallatin National Forest access report. Bozeman, MT: U.S. Department of Agriculture, Forest Service, Gallatin National Forest; 1977. 20 p.

U.S. Department of Agriculture, Forest Service. Environmental assessment for Clark's Fork Snowmobile Trail. Powell, WY: U.S. Department of Agriculture, Forest Service, Shoshone National Forest, Clarks Fork Ranger District; 1982. 65 p.

U.S. Department of Agriculture, Forest Service. Environmental assessment for the West Gardiner Access Unit. Gardiner, MT: U.S. Department of Agriculture, Forest Service, Gallatin National Forest, Gardiner Ranger District; 1984.

U.S. Department of Agriculture; U.S. Department of the Interior. Guidelines for management involving grizzly bears in the Greater Yellowstone area. Bozeman, MT; 1979. 136 p.

U.S. Government. [Proposed rules for critical habitat delineation]. In: Federal Register, Vol. 41, No. 215; 1976 November 5. Washington, DC: U.S. Government Printing Office; 1976.

U.S. Government. The Endangered Species Act as amended by Public Law 97-304-1982. Washington, DC: U.S. Government Printing Office; 1983. 53 p.

AVAILABILITY/UTILIZATION OF GRIZZLY BEAR HABITAT COMPONENTS ON THE ROCKY MOUNTAIN EAST FRONT

Keith Aune and Tom Stivers

ABSTRACT: Seventeen grizzly bear habitat components have been identified on the Rocky Mountain East Front and the availability/utilization of those components was assessed as part of the East Front grizzly studies. Habitat utilization was determined through habitat data gathered at the sites of 1,400 radio relocations during 1980-84. Habitat availability was determined through a nonmapping technique using 5,600 random points within occupied habitat. The analysis identified several habitat components that are used significantly more or less than the seasonal availability. Those components are discussed in detail. An analysis of the availability/utilization of habitat components in relation to roads has also been completed. The road analysis indicated that for spring range, while most of the preferred habitat components are near roads, the use of preferred components away from roads is greater than their availability.

This information is available in:

Aune K; Madel, M.; Hunt, C. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife, and Parks; 1986. 239 p.

Aune, K. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Department of Fish, Wildlife, and Parks; 1985. 138 p.

Aune, K.; Stivers, T. Ecological studies of the grizzly bear in the Pine Butte Reserve. Helena, MT: Montana Department of Fish, Wildlife, and Parks; 1985. 153 p.

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Session III—General Habitat Considerations

Chaired by:

L. Jack Lyon, Research Biologist and Project Leader, Intermountain Research Station, Missoula, MT

USING SATELLITES TO EVALUATE ECOSYSTEMS AS GRIZZLY BEAR HABITAT

John J. Craighead, F. Lance Craighead and Derek J. Craighead

ABSTRACT: Remote sensing has proven to be a precise, highly quantitative tool for describing, mapping, and evaluating grizzly bear habitat on an ecosystem basis. Using the Landsat satellite's multispectral scanner system (MSS), habitat maps of a 4,592 km^2 (1,773 mi^2) area were constructed and refined in Montana's Lincoln-/Scapegoat and Bob Marshall wilderness areas. This technique was further tested in northwest Alaska over a 4,144 km^2 (1,600 mi^2) area. Several satellite systems currently gather spectral data from the surface of the earth. These data, recorded on four to seven spectral bands, are a measure of the reflectance of vegetation and other surfaces. To relate digital image data to vegetation types, intensive ground-truthing (botanical sampling) is needed. A simple, replicable, relevé-type of sample plot is discussed, as well as techniques of interpreting these data and applying them to ecological studies. An agreed-upon, standardized method of describing vegetation with satellite mapping is needed as applications of the technique become widespread. Using standardized techniques, entire ecosystems can be mapped, quantified, and interpreted in terms of vegetation complexes, which are vegetation/ habitat types with similar spectral reflectance values. These large units and their subunits can be described in terms of percent coverage and percent occurrence of plant species. Comparisons can then be made between ecosystems on all or some of these levels. This technique is presently the only practical method for obtaining precise quantitative data on an ecosystem basis and for making meaningful comparisons among ecosystems.

INTRODUCTION

In North America, designated wilderness areas are essential habitat for grizzly bears; they protect the last remaining pristine conditions of native flora and fauna. To preserve the ebb and flow of wilderness for social, aesthetic, and scientific purposes, it is necessary to learn more about the intricate interplay of fauna and flora. Compiling baseline data on the species and plant communities is the necessary first step, and using satellite imagery is the most promising method for obtaining this information over large areas of wilderness.

At this point in the development of satellite mapping techniques it would be wise to standardize the methods used in delineating vegetation complexes (vegetation/habitat types with similar spectral reflectance values) and in collecting sample plot data. The methodology developed in a study of grizzly bear habitat in the Lincoln/ Scapegoat Wilderness Area in Montana (Craighead and others 1982) was further tested and refined in a recent study which mapped the area surrounding the Squirrel River in northwestern Alaska where the intergradations between vegetation complexes were, in many cases, more subtle than those encountered in Montana. The techniques used to produce accurate habitat maps describing vegetation complexes in terms of plant species and plant communities, and the practical applications of this technology for the management of wildlife on an ecosystem basis, are the subject of this paper.

THE MAPPING SYSTEM

The Landsat satellites gather a continuous series of digital images of the earth's surface from a polar orbit at an altitude of about 900 km (560 mi) using scanning systems that record radiant energy over a wide spectrum of wave lengths. The multispectral scanning system (MSS) collects the digital image data that were used to define ecological vegetation complexes in wilderness areas in Montana and Alaska.

The basic spectral unit, the picture element or "pixel," represents a rectangular area on the earth's surface of 4,530 m^2 (48,761 ft^2) with the MSS imagery. Landsat thematic mapper (TM) data can define a smaller area, about one-fifth this size: 900 m^2 (9,688 ft^2). A pixel defines the lower limit of resolution of the system; the reflectance over the entire pixel is averaged to give a single value. This means that in many instances the mapping system is useful for applications varying in scale from 0.09 ha (1/5 acre) to the area of an entire ecosystem. Using a digital image analyzer interactively, color-coded maps are constructed pixel by pixel from the multispectral data. When merged with topographic models (1:63360 to 1:250,000) of the area, a digital map and data base are produced as the final product of this mapping system.

The term "ecosystem," as used here, refers to a large biogeographical area supporting a common ecological vegetation classification. An ecosystem can be classified into a number of vegetation complexes (10 to 20) using spectral data gathered by the satellite scanner. These

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30 - May 2, 1985.

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areas of similar spectral reflectance usually represent areas of similar vegetation. Vegetation sample plot data (or "ground-truth") from each of these complexes can then be used to describe each complex in terms of percent cover and frequency of occurrence of plant species and plant communities. Any of a number of intermediate habitat-type groupings, such as forest habitat types (FHT), ecological land units (ELU), or plant series, can be used depending on the needs of the user (Craighead and others 1982).

SATELLITE TECHNOLOGY

Scanning Systems

Three currently operational systems are the most promising for ecosystem mapping and evaluation. They provide digital image data of the earth's surface with different degrees of resolution. The thematic mapper (TM) has the finest resolution, followed by the multispectral scanning system (MSS), and the advanced very high resolution radiometer (AVHRR). The TM and MSS systems are aboard Landsat satellites that orbit the earth at altitudes varying from 900 to 949 km (560 to 590 mi). Each satellite makes 14.5 sun-synchronous, polar orbits per day, completing an orbit every 103 min. They scan adjacent areas on successive daily orbits, moving from east to west, covering the earth's surface every 16 days and thus updating any particular area at 16-day intervals.

The NOAA satellites, with the AVHRR system, provide digital image data with less resolution than the Landsat systems. The NOAA satellites are also sun-synchronous, polar orbiting, at an altitude of 850 km (527 mi) and a period of 102 min.

Multispectral Scanning System (MSS)

The MSS records digital image data in four spectral bands: band No. 4 (0.5 to 0.6 um), band No. 5 (0.6 to 0.7 um), band No. 6, photographic infrared (0.7 to 0.8 um) and band No. 7, near infrared (0.8 to 1.1 um). The intensity of reflected radiation is recorded as a continuous data strip. This is later converted into a series of frames, each covering an area of 185 by 185 km (115 by 115 mi). Data from two bands, Nos. 5 and 7, were used to define the spectral signature of vegetation complexes in the Montana and Alaska studies.

Thematic Mapper (TM)

The TM records digital image data in seven spectral bands. For habitat mapping, band No. 2, (0.52 to 0.6 um) and the near infrared band No. 4, (0.76 to 0.90 um), are generally used. The distinct advantage in using TM data is the finer resolution. In many cases this should allow finer distinctions to be made in mapping smaller vegetation units. In other cases, especially when mapping large areas, such resolution may be more confusing than helpful. A positive advantage of the thematic mapper over MSS is the significant increase in gray level (signal quantization level) values (64 for MSS versus 256 for TM). This allows finer distinctions to be made in differentiating habitat types. The new French SPOT satellites will also provide high resolution data.

Advanced Very High Resolution Radiometer (AVHRR)

The AVHRR system uses a much larger mapping unit than either of the Landsat systems. Each pixel covers an area of 1 km^2 (2.6 mi^2). The area of a single frame is 1 100 km (684 mi) long by 2 700 km (1678 mi) wide, approximately 220 times as large as a Landsat frame. The newer NOAA satellites record data on seven bands that include three thermal channels. The red (0.55 to 0.68 um) and near infrared (0.73 to 1.1 um) bands are wider than the MSS bands but are adequate for mapping green vegetation (Tucker and Gatlin 1984). Because of the wider swath width, more frequent but less definitive area coverage is possible. It should be useful to map large areas of less diverse vegetation such as the North Slope of Alaska and to show seasonal phenology of growth and development.

Each system has advantages and disadvantages, but all have useful applications and can complement one another in studies involving a number of ecosystems. Because of the inherent problems in satellite scanning (cloud cover and timing of satellite passes), one system may have the necessary coverage of an area when another does not.

GROUND-TRUTHING

To use any satellite system to map vegetation, a direct relationship must be established between the digital data and the vegetation that it represents. Techniques to accomplish this are termed "ground-truthing". Four ground-truthing techniques were used.

1. In Montana a vegetation-type map of the primary study area was initially produced, on the ground, for subsequent comparison with the satellite digital map.
2. Aerial photographs, aerial reconnaissance, and site visits determined training sites: i.e. large homogeneous areas of vegetation that represent a vegetation complex.
3. Digital maps were taken into the field and the boundaries of vegetation complexes were compared with the actual habitat boundaries.
4. Descriptive data were compiled from vegetation sample plots located in each vegetation complex.

In Montana, relevé-type plots recording estimates of cover were used for sample data. Percent cover in herbaceous community types was estimated to the 5 percent level on plots of 108 m^2

(1,156 ft^2). Forest vegetation was sampled similarly on plot sizes of 809 m^2 (8,708 ft^2). Species occurring at less than the 5 percent level were recorded as trace species. Percent cover was estimated for three strata: tree (>3 m), shrub and dwarf tree (0.6 m to 3 m), and ground cover. Ground cover plus bare ground was estimated to equal 100 percent.

In Alaska, the same plot sizes were used. Percent cover was estimated to the 1 percent level on all plots. In addition to the three strata estimated in Montana, an attempt was made to estimate coverage of a sublayer of sphagnum and lichen species whenever possible.

STUDY AREAS

Representative study areas for intensive ground-truthing are essential to the mapping system. These can be small and numerous or large and few. They must represent the full range of vegetation within the ecosystem, so that study site data can be extrapolated to other areas of the ecosystem.

From 1977 to 1982 a comprehensive vegetation map was developed and refined for a 4,592 km^2 (1,773 mi^2) area in the Lincoln/Scapegoat and Bob Marshall Wildernesses in central Montana (fig. 1). Initially, a detailed vegetation ground map was developed in the 204-km^2 (70-mi^2) primary study area. A first-generation Landsat map was then ground-truthed in this area to produce a refined, second-generation Landsat map.

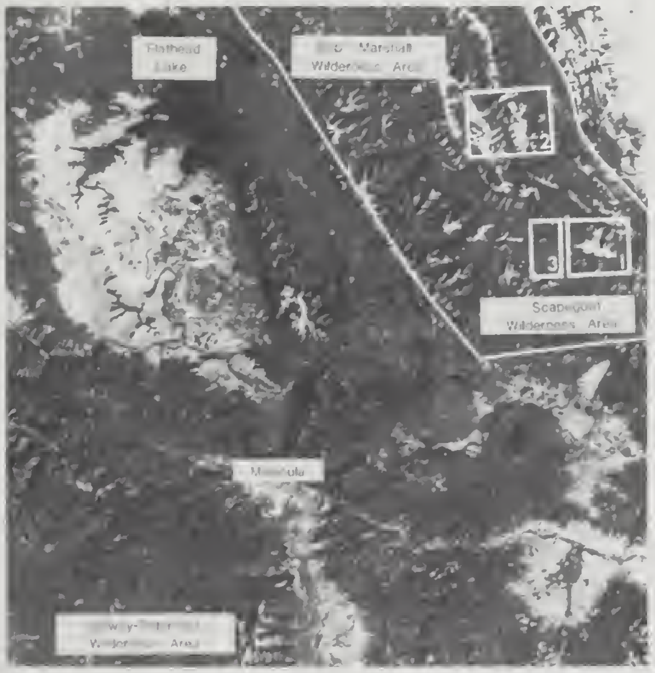

Figure 1.—The Montana study areas: 1) Scapegoat Plateau--primary study area; 2) Slategoat Plateau--secondary study area; 3) Danaher--secondary study area.

The second-generation classifications were extrapolated to secondary study areas, Slategoat and Danaher. Here additional ground-truthing verified the accuracy of the extrapolation process to a total area of 645 km^2 (249 mi^2). On the basis of this and extensive ground surveys, a third refinement was made in order to accurately extrapolate the resultant vegetation complexes from this third-generation map to the entire 4,592 km^2 (1,773 mi^2) area (fig. 2).

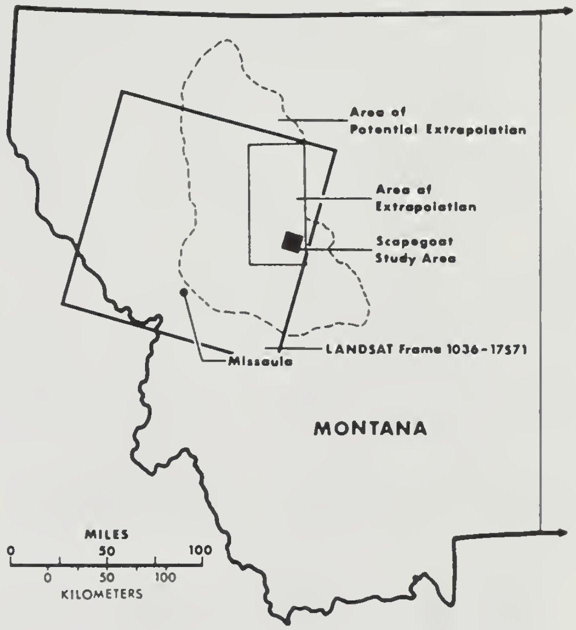

Figure 2.--The Montana study areas: area of extrapolation of third-generation map.

In 1983 and 1984, first- and second-generation maps were developed for a 4,144-km^2 (1,600-mi^2) area in northwestern Alaska, which encompassed the Squirrel River and the Kobuk River Delta (fig. 3). Ground-truthing sites were scattered throughout the area as shown.

Figure 3.—The Alaska study area: 1) Kobuk Peak; 2) Kiana Hills; 3) Squirrel River; 4) Baird Mountains; 5) Kobuk Delta; 6) Baldwin Peninsula; 7) Kobuk Lake; 8) Selawik Lake; 9) Noatak River.

ECOSPECTRAL CLASSIFICATION

Converting digital image data into useful ecospectral classifications that represent natural plant groupings is an iterative process that requires two or three successive refinements (Craighead and others 1982). An overview of the process is depicted in figure 4.

Initially, a cloud-free digital tape of the area of interest is obtained from an EROS Data Center, and study sites are tentatively located on the imagery. This is followed by a reconnaissance of the proposed study areas, examination of high-altitude photos (color and infrared), and on-site inspections. Large areas of homogeneous vegetation representing distinct classes of vegetation (for example, forest, tundra, shrubland) are precisely located on topographic maps or orthophotos to be used as training sites, which are areas of known location with a relatively uniform vegetation type throughout the study area. Generalized ground-truth information is obtained, and limited vegetation sample plots are taken. By analyzing the digital data from training site locations on the satellite imagery, a characteristic composite of spectral values, or a "signature," is computed and assigned to each vegetation complex. Data from several training sites are averaged to determine each signature. An ecospectral classification results, with each

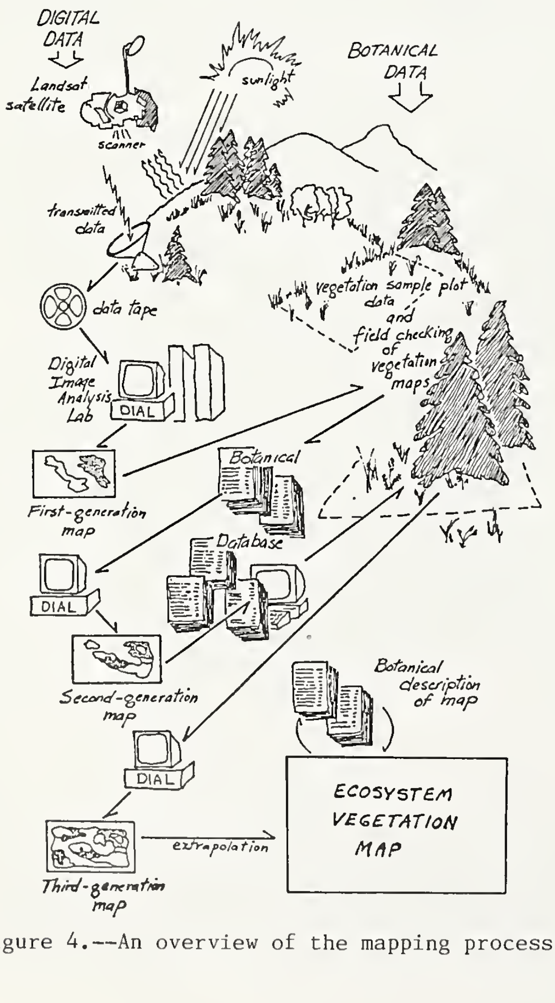

Figure 4.--An overview of the mapping process.

spectral group or vegetation complex assigned a color code. Then, using the digital image analyzer (IMAGE 100) interactive computer, a computer map is constructed with areas of similar vegetation having the same color code. When using a supervised classification technique such as this, the type of vegetation in each complex is known beforehand, but the exact botanical composition of each complex is unknown. To determine what each vegetation complex represents on the ground requires botanical sampling. Once this has been accomplished, the colored mosaic of complexes with their botanical descriptions then comprise a thematic vegetation map.

The type of vegetation complex that can be resolved from a spectral signature is limited by the resolution of the scanning system. Thus, it is necessary to first construct a vegetation map of the spectral groups and then describe these spectral groups or vegetation complexes in terms of their botanical composition from on-the-ground studies. When a hierarchical vegetation classification is used to describe the vegetation representing each spectral group, the result is a spectral-vegetation classification, or "ecospectral classification" (Craighead and others 1982). Attempts to generate spectral values for predetermined vegetation groupings have not proved productive, and such efforts were responsible for some early disillusionments with Landsat as a mapping system.

Montana

In the Montana study, three successive classification refinements were made in the habitat map. This was accomplished as follows. Using the first-generation ecospectral map, sample plots were located in representative areas to describe each of six vegetation complexes. During the 1975 and 1976 field seasons, 487 sample plots were taken. Systems existed for habitat-typing forests and grass-shrublands, and each sample plot could be assigned to a forest habitat type (FHT) (Daubenmire and Daubenmire 1968; Pfister and others 1977) or ecological landtype (ELT) (Mueggler and Handl 1974). No comparable system existed for typing alpine vegetation, so a classification was developed using the ecological land unit (ELU) (Corliss and others 1973) as the basic grouping of similar plant communities. The vegetation complex, each with a unique spectral signature, could represent any one of a number of vegetation system/land system combinations. For example, the alpine meadow complex (fig. 5) was a community-type land unit, whereas the xeric Pinus albicaulis forest complex (fig. 6) was a series-landtype association of forest habitat types. Both complexes are subdivided to the plant community and species level. The larger units of the system are expressed in percent area; the smaller units in percent vegetation cover.

These basic vegetation groupings were further distinguished by altitudinal zones. Originally

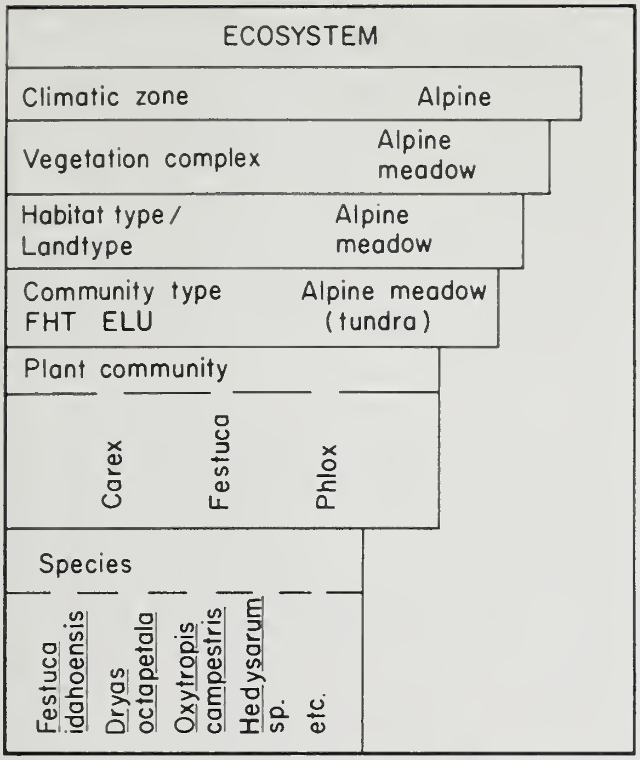

Figure 5.--Sub-divisions of the alpine meadow vegetation complex.

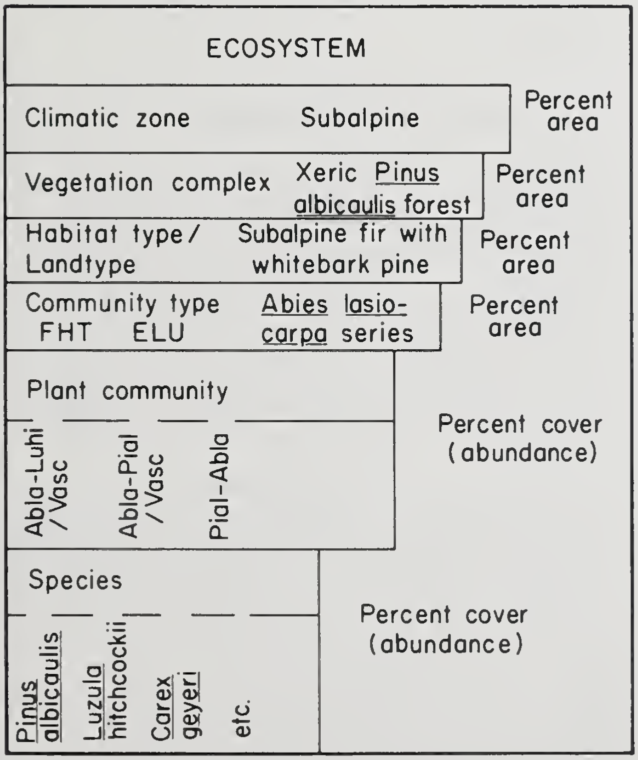

Figure 6.--Sub-divisions of the xeric Pinus albicaulis forest complex. Large units of the system are expressed as percent area; small units as percent cover.

only six spectral signatures were used to delineate vegetation complexes; however, sample plot data indicated a difference in plant composition above and below 2,317 m (7,600 ft) for one complex, which was then divided into the alpine meadow and subalpine parkland complexes by means of a "signature polygon." A signature polygon is a discrete area delineated by digitized elevation data and spectral signatures. The digital image analyzer is used to assign a different color to this area and to separate it as a recognized vegetation complex. Similarly, another vegetation complex was differentiated into mesic subalpine fir and mixed coniferous forest by a signature polygon drawn at the 2,317-m (7,000-ft) contour. The ground-truth map of the primary study area was then checked against the habitat map developed from digital image data. (For more details see Craighead and others 1982).

These eight spectral signatures from the Scapegoat primary study area were then used to generate maps of the Slategoat and Danaher secondary study areas. The resultant maps were termed second-generation maps. Test sites were established in the secondary study areas to determine the accuracy of the extrapolation.

After field-checking the second-generation map and taking additional sample plots, a third-generation map was developed utilizing nine spectral and four polygon signatures to delineate 13 vegetation complexes. This map showed an accuracy of 93 percent and was subsequently extrapolated to a 4,592-km^2 (1,773-ft^2) area of wilderness surrounding the Scapegoat study area.

Alaska

In the Alaska mapping project of 1983-85, two generations of digital image maps have been developed. Experience from the Montana study enabled the methodology to be streamlined somewhat. Training sites were located on U.S. Geological Survey maps, and after aerial reconnaissance, 40 sample plots were taken in representative plant communities. These data were used to develop a first-generation map of 12 vegetation complexes. This map was field-checked during the summer of 1984. To botanically describe the vegetation complexes identified from spectral values, 627 sample plots were taken in representative plant communities. In Alaska, a comprehensive, hierarchical system of vegetation classification had already been established (Viereck and Dyrness 1980; Viereck and others 1982), and it was only necessary to incorporate it into the spectral classifications obtained from satellite data to develop an ecospectral classification. As in Montana, a spectral signature for a vegetation complex could represent a wide or a narrow range of plant groupings (fig. 7). Some complexes such as the feltleaf willow complex (Salix alaxensis) represented only one plant community but registered a consistent, distinctive reflectance value. The greenleaf

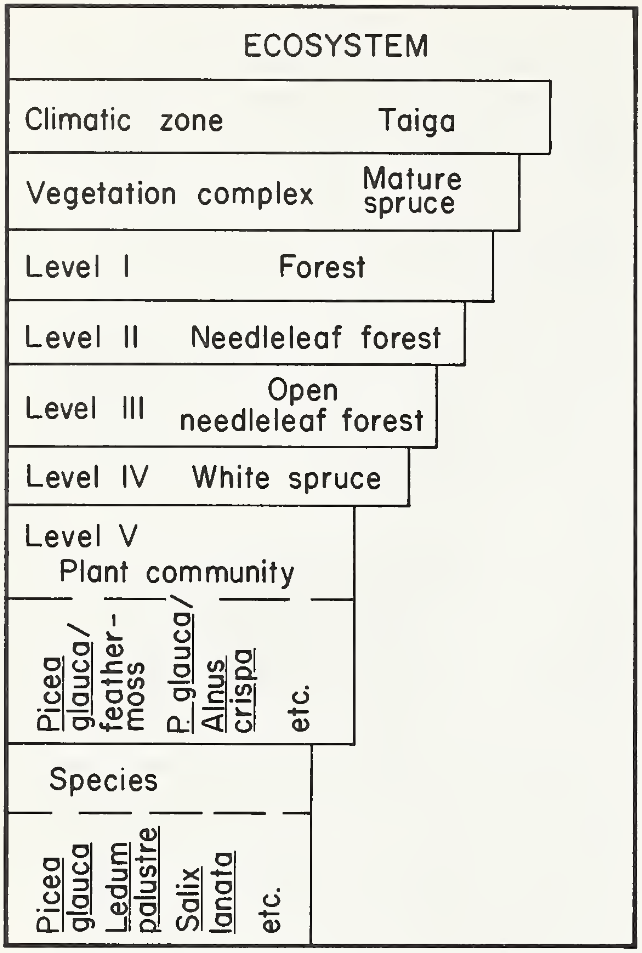

Figure 7.--Sub-divisions of the mature spruce vegetation complex.

willow complex was also distinctive but comprised 11 plant communities with three codominant willow species: Salix lanata, S. planifolia, and S. glauca. Other complexes such as the tussock tundra complex represented a still greater variety of plant communities composed of several codominant species.

A second-generation map was developed in early 1985 by adjusting signature polygons to comply with elevational field data and vegetation surveys. In the Kobuk delta region, several distinctive signatures were grouped into a riparian vegetation mosaic to produce a less confusing color map. We are in the process of extrapolating the classification to an area of approximately 129,500 km^2 (50,000 mi^2).

SAMPLE PLOT ANALYSIS

Sample plot data were grouped according to the vegetation complex in which they were collected and summary statistics were computed. In the Montana study, the data were further divided subjectively into ecological land unit (ELU), ecological land type (ELT), and forest habitat type (FHT) groupings. By type-mapping the entire primary study area, relative abundance of each type in a vegetation complex was determined. Percent vegetative cover of each species was determined from sample plot data by dividing the total percent cover for each species by the total percent cover for all species and percent occurrence of plant species was determined in a similar manner: if a species represented 5 percent or more of the cover within a plot, it was counted as occurring in that plot. The total percent occurrence for a species was determined by dividing the total number of plots in which the species occurred by the total number of plots taken in the specific ELU, ELT, or FHT (Craighead and others 1982).

In the Alaska study, sample plot data were entered into a separate computer data base for each vegetation complex in which they occurred. Summary statistics for each species were computed in the vegetation complex and calculated percent vegetation cover and percent occurrence. Average ground cover was determined by dividing the sum of all recorded cover estimates by the number of plots taken in that vegetation complex, which gave an average percent cover of that species in any plot.

Vegetation sample plots were then subjectively grouped into plant communities, based on the classes compiled by Viereck and Dyrness (1980) and Viereck and others (1982) to estimate the relative coverage of each plant community in a vegetation complex. Plant community descriptions are incomplete for some habitat types in north-western Alaska and several new descriptions resulted.

CAPABILITIES OF THE MAPPING SYSTEM

The mapping system is not limited to classifying large vegetation units defined by spectral signatures. Units smaller than the vegetation complex can be computer mapped but cannot be extrapolated. If for example, there is an area of interest of from 0.38 to 76.8 km^2 (1 to 20 mi^2) containing a drainage pattern or a series of mountain slopes that needs to be mapped and quantified, this can readily be done. First, the latitude and longitude of the area of interest is determined. The area can then be located on the MSS digital tape and video displayed. Signature polygons can be developed for the riparian habitat or for any number of vegetation sites or animal use locales known to exist within the area. These can be as discreet as a single, large plant community or a combination of several of these. Similarly, land form units as small as the ecological land unit (ELU) or a site of high animal use about 0.4 ha (1 acre) in extent can be mapped. Color codes are assigned, and thus a color-coded or thematic map with units more definitive than the vegetation complex can be computer-constructed and then printed and enlarged for field use.

These maps can be used to interpret similar small land areas located throughout the ecosystem even

though the data cannot be extrapolated to other areas. Both the small polygon-defined sites and the large spectrally defined vegetation complexes are subject to total area computation and to statistical analyses of interspersion, juxtaposition, and habitat diversity.

To further illustrate the application, assume there is a 25.9-km^2 (10-mi^2) area of heavily used grizzly bear habitat. In this area, vegetation complexes (which can be extrapolated to the entire ecosystem) and small dispersed areas 0.4 to 4.0 ha (1 to 10 acres) of riparian marshland and specific avalanche slopes (which cannot be extrapolated) need to be mapped. This area can be mapped by applying data gathered in the field. Polygons are drawn around all the specific sites using an interactive computer. These are color coded and incorporated into the digital base map displaying the vegetation complexes. Readouts of area statistics can be obtained for both the large and the small units. Any site of specific interest that can be located in the field or identified from aerial photographs can be delineated on the digital image map and assigned an identifying color. The total area of any site or group of similar sites is instantly available from the digital map data base. Using a satellite imagery data base can thus enhance and clarify aerial photography mapping efforts and, conversely, conventional mapping techniques can be integrated with the digitized ecosystem classification.

ECOSYSTEM ANALYSIS

Ecosystems accurately mapped and quantitatively described can be compared to show existing similarities and differences using one or more of the satellite imagery systems (MSS, TM, and AVHRR). This can be accomplished at a number of levels. Starting with the larger classification units, comparisons can be made of bioclimatic zones: the vegetation of the alpine zone of one biogeographic area with the alpine zone vegetation of another, the subalpine with subalpine, and temperate with temperate. Decreasingly smaller vegetation units such as forest series, vegetation complexes, forest habitat types (FHT), and plant communities can be compared and analyzed.

In addition to comparing specific vegetation categories between ecosystems, it is feasible to computer-analyze, from the digital data base, such parameters as ecological diversity, percent abundance of a specific plant, or the abundance of preferred bear food plants.

COMPARISONS AMONG ECOSYSTEMS

Comparing the Alaska study area at latitude 67° N with the Montana site at latitude 47° N presents a far more difficult task than comparing ecosystems that are more similar in geographic location and in terrain features; however, at the present time these are the only areas for which there are comparable data. These preliminary comparisons are offered primarily as illustrations of what is possible and what is needed. If and when the Yellowstone and Selway/Bitterroot areas are mapped by digital imagery, a more direct and comprehensive comparison can be made between these and the Northern Continental Divide than is possible between geographic sites in Montana and Alaska. These differences, as well as similarities, can be tabulated, quantified, and used to interpret habitat quality and habitat use by grizzly bear populations.

In general, ecosystem data can be compared on three levels. On a macroscale, comparisons can be made between similar vegetation complexes. On a microscale, species and plant communities can be compared. At the present time, the data from the Montana study area have not been analyzed in terms of plant communities so it will only be pointed out that this can be done. It may be that these comparisons of identical, or ecologically equivalent, plant communities will be the most meaningful in terms of grizzly bear ecology.

On a macroscale, data from the digital vegetation maps are summarized in table 1. The data have been grouped to allow comparisons to be made between the alpine zones, the forests, and the other complexes (herbaceous and shrubs). The alpine zones in both areas comprise a similar percentage of the total vegetation. On the other hand, the amount of forested areas is very dissimilar: 62.05 percent in Montana versus 22.64 percent in Alaska. The other vegetation complexes are scarcely comparable: the Alaskan area extends from sea level and has a greater diversity of herbaceous and shrubland habitat types as well as a significant amount of water. Any similarities in the two areas are most likely to be found in the alpine zones.

The alpine zones of both sites have similar terrain that can be divided by spectral values into two comparable complexes; the alpine meadow, or tundra, and the vegetated rock. Some microscale comparisons between these vegetation complexes are offered to illustrate how the comparative process can work.

Table 2 shows the percent vegetative cover in the vegetated rock complex. Only two species, Dryas octopetala and Silene acaulis, were identical; D. octopetala comprised almost three times as much cover in Alaska as in Montana. In Montana, bear food plants are almost 10 times as abundant as they are in the same vegetation complex in Alaska when only the bear food plants are compared:

	Alaska	Montana
Percent vegetation cover	5.4	46.8
Average ground cover	2.3	18.7

The Alaskan alpine tundra and the Montana alpine meadow complexes were also compared. Again, Dryas octopetala was the major identical species, comprising twice as much cover in Alaska (table 3), although several genera with similar species

Table 1.—Area comparisons: Montana and Alaska digitized vegetation maps

Montana vegetation complexes (159,456 acres)	Percent of total	Alaska vegetation complexes (886,949 acres)	Percent of total
Alpine		Alpine	
Alpine meadow	5.29	Alpine tundra	6.76
Vegetated rock	3.44	Vegetated rock	2.28
Bare rock I	4.50	Bare rock	.28
Bare rock II	3.58	Alpine shrubland	7.92
Subtotal	16.81	Subtotal	17.24
Forest		Forest	
Xeric *Pinus albicaulis*	4.77	Young dwarf spruce forest	15.12
Mesic *Abies lasiocarpa/ Pinus albicaulis* forest	11.89	Mature spruce forest	7.52
Xeric *Abies lasiocarpa/ Pseudotsuga menziesii* forest	9.08	Subtotal	22.64
Mixed coniferous temperate forest	36.31		
Subtotal	62.05		
Other		Other	
Subalpine parkland	7.37	Feltleaf willow	2.68
Temperate parkland	9.85	Greenleaf willow	5.18
Carex-Salix marsh	.70	Shrub tundra	6.84
Equisetum seepage	.27	Tussock tundra	27.40
Scree	2.44	Equisetum-sedge marsh	2.24
Unclassified	.51	Semi-vegetated areas	2.17
Subtotal	21.14	Bare gravel bars	.05
		Burn	2.28
		Water	11.27
		Subtotal	60.11
Total	100.00	Total	99.99

Table 2.—Vegetated rock complex species comparisons

Montana vegetation (n=70)	Percent	Alaska vegetation (n=15)	Percent
**Dryas octopetala*	24.8	*Dryas octopetala*	71.22
***Carex* spp.	19.2	Unidentified *Carex* spp.	1.43
Festuca idahoensis	10.5	*Loiseluria procumbens*	4.61
***Arctostaphylos uva-ursi*	7.4	*Arctostaphylos alpina/rubra*	.16
***Salix* spp.	5.3	*Salix phlebophylla*	12.40
Phyllodoce spp.	3.9	*Diapensia lapponica*	1.75
Juncus parryi	3.3	*Carex membranacea*	.79
Trace forbs	3.3	Trace forbs	3.18
Gramineae spp.	2.8	Unidentified Gramineae spp.	.95
Potentilla fruiticosa	2.3	*Oxytropis nigrescens*	.64
Phlox pulvinata	2.3	*Carex microchaeta*	.64
Antennaria spp.	2.1	*Hierchloe alpina*	.48
Gentiana calycosa	1.3	*Betula nana*	.32
***Salix arctica*	1.1	*Artemesia arctica*	.16
Claytonia megarhiza	1.0	*Vaccinium uliginosum*	.16
Potentilla diversifolia	1.0	*Ledum palustre*	.16
Ranunculus eschsholtzii	.8	*Minuartia arctica*	.16
Hedysarum spp.	.8	*Carex scirpoidea*	.16
Lomatium cous	.8	*Empetrum nigrum*	.16
Luzula hitchcockii	.7		
Arabis spp.	.7		
Achillea millefolium	.7		
Arenaria spp.	.5		
Anemone spp.	.5		
Cardamine rupicola	.5		
Penstemon ellipticus	.3		
Hedysarum sulphurescens	.3		
Claytonia lanceolata	.2		
**Silene acaulis*	.2	*Silene acaulis*	.16
Fragaria virginiana	.2		
Besseya wyomingensis	.2		
Erigeron spp.	.2		
Erthronium grandiflorum	.2		
Pedicularis spp.	.2		
Valeriana spp.	.2		
Astragalus bourgovii	.2		
Saxifraga spp.	.2	*Saxifraga oppositifolia*	.32
Poa alpina	.2		
Total	100.4	Total	100.01

* Species that appeared in both Montana and Alaska (excluding trace species).
** Genera that appeared in both Montana and Alaska (excluding trace species).

Table 3.--Alpine tundra/meadow complex species comparisons

Montana vegetation (n=101)	Percent	Alaska vegetation (n=56)	Percent
**Carex spp.	19.5	Unidentified Carex spp.	21.46
Festuca idahoensis	15.2	Dryas spp.	3.23
*Dryas octopetala	6.5	Dryas octopetala	13.28
**Arctostaphylos uva-ursi	5.1	Arctostaphylos alpina/rubra	1.34
Phlox pulvinata	4.9	Dryas integrifolia	3.01
Thalictrum occidentale	4.3	Equisetum arvense	10.15
Luzula hitchcockii	3.6	Moss and lichen	8.25
Gramineae spp.	2.8	Unidentified Gramineae spp.	1.58
Ranunculus eschscholtzii	2.4	Carex bigelowii	6.90
Trace forbs	2.4	Trace forbs	2.03
**Salix arctica	2.3	Salix arctica	.82
**Oxytropis campestris	1.9	Oxytropis spp.	.05
**Potentilla fruiticosa	1.9	Potentilla biflora	.18
**Anemone parviflora	1.8	Anemone narcissiflora	.04
Valeriana spp.	1.6	Salix reticulata	3.50
**Hedysarum spp.	1.6	Hedysarum alpinum	.22
Potentilla diversifolia	1.5	Betula nana	3.44
Caltha leptosepala	1.5	Eriophorum vaginatum	2.99
**Vaccinium scoparium	1.4	Vaccinium uliginosum	6.72
Gentiana calycosa	1.4	Vaccinium vitis-idaea	.18
Achillea millefolium	1.3	Cassiope tetragona	2.74
Erythronium grandiflorum	1.1	Empetrum nigrum	.88
Polygonum spp.	1.0	Ledum palustre	.84
Antennaria spp.	1.0	Lupinus arcticus	.56
Astragalus spp.	1.0	Hierchloe alpina	.45
Eritrichium nanum	.9	Boykinia richardsonii	.43
Astragalus bourgovii	.9	Calamagrostis spp.	.39
Juncus parryi	.7	Poa spp.	.36
Erigeron spp.	.7	Carex scirpoidea	.23
Arnica latifolia	.6	Allium schoenoprasum	.22
Erigeron simplex	.5	Salix phlebophylla	.16
Lomatium spp.	.4	Heracleum lanatum	.16
Senecio triangularis	.3	Arctagrostis latifolia	.14
Arenaria spp.	.3	Mertensia paniculata	.09
Douglasia montana	.3	Geum glaciale	.07
Senecio megacephalus	.3	Eriophorum angustifolium	.04
Pedicularis groenlandica	.3	Silene acaulis	.04
Erigeron speciosus	.3	Diapensia lapponica	.02
**Hedysarum sulphurescens	.3	Epilobium angustifolium	.02
Arabis nuttallii	.3	Luzula spp.	.02
Valeriana edulis	.3	Luzula tundricola	.02
Pedicularis spp.	.2	Loiseluria procumbens	.02
Dodecatheon spp.	.2	Lycopodium spp.	.02
**Anemone multifida	.2	Rhododendron lapponicum	.02
Polygonum bistortoides	.2	Rubus chaememorus	.02
**Calamagrostis rubescens	.2	Saussurea viscida	.02
**Galium boreale	.2	Galium boreale	.05
Solidago multiradiata	.1	Spirea beauverdiana	.02
Besseya wyomingensis	.1		
Veronica spp.	.1		
Cirsium scariosum	.1		
Ribes spp.	.1		
**Salix spp.	.1	Unidentified Salix spp.	2.53
Lomatium cous	.1		
Poa spp.	.1		
Fragaria virginiana	.1		
Hieracium spp.	.1		
Pedicularis contorta	.1		
Phyllodoce spp.	.1		
Penstemon ellipticus	.1		
Juniperus communis	.1		
Delphinium bicolor	.1		
Lloydia serotina	.1		
Cardamine rupicola	.1		
**Claytonia lanceolata	.1	Claytonia acutifolia	.02
Physaria didymocarpa	.1		
Arabis spp.	.1		
**Saxifraga spp.	.1	Saxifraga hirculus	.02
Polygonum viviparum	.1	Saxifraga oppositifolia	.05
Senecio integerrimus	.1		
Hackelia micrantha	.1		
**Potentilla gracilis	.1		
Total	100.1	Total	100.06

Shrub Layer	
Alnus crispa	25.64
Betula nana	17.95
Salix alaxensis	5.13
Salix glauca	2.56
Salix planifolia	35.90
Unidentified Salix spp.	12.82
Total	100.00

* Species that appeared in both Montana and Alaska (excluding trace species).
** Genera that appeared in both Montana and Alaska (excluding trace species).

in both areas were also found. For example, Hedysarum alpinum comprised 0.2 percent of the vegetative cover in Alaska, whereas H. sulfurescens and H. occidentale together comprised 1.9 percent in Montana.

A comparison of all bear food plants shows the alpine meadow complex in Montana to have a bear food plant abundance twice that of its Alaskan counterpart. The greater amount of bare ground in the Montana alpine meadow study plots, however, means that if overall ground cover is calculated, the percentages are closer: 22.2 percent in Alaska versus 36.9 percent in Montana.

	Alaska	Montana
Percent vegetation cover	22.7	51.6
Average ground cover	22.2	36.9

Comparisons of total bear food plant abundance (percent vegetative cover) indicate general habitat quality. More specific comparisons can be made by comparing the abundance of high-preference foods. For example, in alpine tundra/meadow, Claytonia lanceolata (0.01 percent) versus C. acutifolia and C. sarmentosa (0.02 percent together in Alaska); Oxytropis campestris (1.9 percent) versus O. nigrescens (0.05 percent in Alaska); Vaccinium scoparium (1.4 percent) versus V. uliginosum and V. vitis-idaea (6.9 percent together in Alaska). Since food plant species vary greatly in nutritional value, biomass, preference value, and seasonal occurrence, a rating system should be developed to make across-the-board comparisons between ecosystems; however, these examples should illustrate the potential for comparing grizzly bear habitat on a species-by-species or a plant-community-by-plant-community basis between similar ecosystems.

Standardization

As the previous examples illustrate, comparisons between ecosystems require standardized procedures and techniques. Comparisons can focus on differences or on similarities. To analyze these quantitatively, it is necessary to map both ecosystems on a common scale and with similar techniques. The Landsat pixel provides the unit of measurement, the spectral signature provides the mapping technique, and the digital image analyzer provides the means of integrating the two.

Whether vegetation classifications and maps generated from digitized imagery have useful interpretive and comparative value for wildlife management purposes depends on additional standardized ground-truthing of which the most important element is a hierarchical vegetation classification. The various classification levels from series to plant community differ in the two hierarchical classifications discussed. The ecological land type (ELT), ecological land unit (ELU), and forest habitat type (FHT) used to describe groups of plant communities in Montana have no counterpart in the Alaskan classification system. Also the latter system applies to the entire state of Alaska, whereas the Montana classification is largely confined to western Montana, although it has application in adjoining mountain areas. Both classifications are still incomplete, and both will require updating and alterations as ecological and botanical knowledge increases.

To repeat, the most meaningful comparisons from an ecological standpoint can be made by comparing vegetation complexes, plant communities, and species. The Alaska data have been grouped into plant communities, each sample plot yielding one data point. The data from the Montana study will soon be grouped in this fashion, forming a common standard for the community and species levels.

An example of the type of plant community statistics that can be developed is shown in table 4. In the alpine tundra complex in Alaska, Dryas octopetala (Droc) communities comprised 28.6 percent of the ground cover sampled and the D. integrifolia (Drin) community comprised 12.5 percent. Vaccinium (Vavi and Vacspp) communities comprised 12.5 percent, and the Equisetum arvense (Eqar) community comprised 14.3 percent.

Table 4.--Northwestern Alaska alpine tundra complex-plant communities

Plant Community	Number of Plots	Percent
Erra-Cabi-Lepa-Vavi	3	5.4
Cabi	4	7.1
Cabi-Bena	4	7.1
Eqar	8	14.3
Cabi-Drin	3	5.4
Drin-Sare-Cabi	4	7.1
Vacspp-Lepa-Emni-Aral	5	8.9
Cabi-Droc	3	5.4
Droc-Case	5	8.9
Droc	2	3.6
Droc-Aral	2	3.6
Droc-Cate	4	7.1
Bena-Vacspp-Emni	2	3.6
Cate	1	1.8
Sare-Salspp/Eqar	4	7.1
Lichen	2	3.6
Total	56	100.0

DISCUSSION

Landsat multispectral imagery in conjunction with vegetation sampling and computer assistance provides a definitive vegetation mapping system based on ecological principles and ecological hierarchical classifications. The system can be applied at the ecosystem level to map, quantify, and analyze vegetation categories within a specified biogeographical area or to compare various plant categories between ecosystems. Ecological classifications as extensive as the

series or as small as plant community groups can be computer-mapped and quantitative, descriptive data can be extracted by computer. Site-specific field data on plant utilization can be manually or electronically entered into the system and such data analyzed in context with area statistics for all or any portion of a given ecosystem. Both the imagery and the data base can be continuously updated.

For the system to become a routine tool in the management of wilderness resources, it will be necessary to do the following.

1. Develop and or complete hierarchical vegetation classification systems for extensive geographic areas (these should include vegetation classes ranging from the series to the plant community).
2. Standardize vegetation field sampling procedures to establish comparable descriptive data bases.
3. Standardize, within the limits of current computer capability, a color-code classification for the vegetation categories high on the hierarchical vegetation classification (for example, shades of green for forest complexes, violet for shrublands, yellow for grasslands.
4. Develop specific botanical and ecological criteria for delineating ecosystems or biogeographical areas (this will improve the accuracy of extrapolation).
5. Standardize terminology wherever possible.

Basing grizzly bear management on population data has been largely unproductive and often highly controversial. It is now possible for wildlife managers to begin managing grizzlies on an ecosystem level through better understanding their ecosystem habitat requirements. The wildlife profession is on the threshold of obtaining a wider view: a satellite window. If the vegetation of an ecosystem can be accurately mapped and quantitatively described (Craighead and others 1982), the next obvious step is to map and compare ecosystems. This is now possible and should open areas of inquiry to plant ecologists and offer numerous advantages to wildlife managers.

Enough is known about the food and habitat requirements of grizzly bears to make it possible to interpret this knowledge in terms of the total area of critical habitat available within an ecosystem, the size and distribution of bear activity centers, food plant abundance, and ultimately carrying capacity. It should be possible to make precise and objective comparisons between the Yellowstone Ecosystem, the Bob Marshall Wilderness, Glacier, and the Selway/Bitterroot, and also to make more meaningful comparisons between bear habitat in Montana and Alaska. By integrating (through specific modeling) cumulative effects with a highly definitive vegetation data base (Christensen and others 1984; Winn and others 1984), it should be possible to predict what wilderness uses will be compatible with a viable grizzly population and obtain a better understanding of the population levels that should be maintainable in any given biogeographical area. With such information obtainable goals can be set, the progress of recovery programs can be judged, and questions confronting policy makers can be asked. For example, where should grizzly bears be perpetuated? How much and what kind of terrain is required? Can a wilderness habitat core support a viable population, or are adjoining multiple use lands essential? What is the optimum bear density for a specific biogeographic area or portion of it? How does bear density compare between ecosystems? What types of information are applicable to more than one ecosystem? How can such knowledge reduce duplication of effort in bear research projects? Finally, what specifically can be done to improve grizzly bear recovery plans and management procedures with comparative ecosystems data?

REFERENCES

Christensen, A; Escano, R; Harrington, P; Hurska, C; Puchlerg, T; Young, L. Technology transfer plan - grizzly bear cumulative effects analysis. U.S. Department of Agriculture, Forest Service, Northern Region. Regional Cumulative Effects Workshop; 1984. 15 p.

Corliss, J. C.; Pfister, R. D.; Buttery, R. F.; Hall, F. C.; Mueggler, W. F.; On, D.; Phillips, R. W.; Platts, W. S.; Reid, J. E. Ecoclass-A method for classifying ecosystems. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 52 p.

Craighead, J. J.; Sumner, J. S.; Scaggs, G. B. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Wildlife-Wildlands Inst. Monogr. No. 1. Missoula, MT: University of Montana Foundation; 1982. 279 p.

Daubenmire, R.; Daubenmire, J. B. Forest vegetation of eastern Washington and northern Idaho. Tech. Bull. No. 60. Pullman, WA: Washington Agricultural Experiment Station; 1968. 104 p.

Mueggler, W. F.; Handl, W. P. Mountain grassland and shrubland habitat types of western Montana. [Interim Report]. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1974. 89 p.

Pfister, R. D.; Kovalchik, B. L.; Arno, S. F.; Presby, R. C. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Tucker, C. J.; Gatlin, J. A. Monitoring vegetation in the Nile Delta with NOAA-6 and NOAA-7 AVHRR imagery. Photogram. Eng. and Remote Sens. 50:(1):53-61; 1984.

Viereck, L. A.; Dyrness, C. T. A preliminary classification system for vegetation of Alaska. Gen. Tech. Rep. PNW-106. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1980. 38 p.

Viereck, L. A.; Dyrness, C. T.; Batten, A. R. Revision of preliminary classification for vegetation of Alaska. Fairbanks, AK: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Institute of Northern Forestry; 1982. 72 p.

Winn, D.; Barber, K; Contreras, G; Green, B. Cartographic models: a holistic approach to wildlife habitat evaluation. U.S. Department of Agriculture, Forest Service, Intermountain Region; 1984. 11 p.

HABITAT SELECTION IN THE BROWN BEAR IN EASTERN FINLAND

Erkki Pulliainen

ABSTRACT: Forty-one brown bear den sites studied in eastern and northern Finland indicate that forests are the most important overwintering areas. Ninety-four stomach analyses showed that animal matter is important from May through July; the importance of plant matter increases toward late summer. During the first half of the summer, bears may be attracted to artificial feeding sites where meat is offered. Berries of Vaccinium myrtillus, Empetrum nigrum, Rubus chamaemorus, and Oxycoccus quadripetalus are decisive in determining habitat selection in late summer. If the bears are not disturbed, habitat selection may not be affected by the presence of humans.

INTRODUCTION

In Finland the brown bear (Ursus arctos L.), which is a close relative of the North American grizzly bear (Ursus horribilis horribilis Ord), spends about half the year in a dormant state and spends the rest of the year recovering from the "stress" of the previous overwintering and preparing for the next dormancy period. This omnivorous carnivore has two or three essential habitats surrounding its winter den and the places where it obtains its food during early and late summer.

This study of brown bear habitat selection is based on recordings of den sites, analyses of stomach contents, direct observations of feeding bears, and observations of the recolonization of Finland by bears.

MATERIAL AND METHODS

The research team analyzed stomach contents of the 47 brown bears killed in eastern and northern Finland from May through July and those of 47 bears killed from August through October. We observed feeding bears at natural and artificial feeding sites in this area and studied 41 den sites.

From 1977 to 1981, the Finnish Border Patrol Establishment systematically recorded crossings of brown bears along the 2 574-km frontier. The wanderings of the migrating bears were followed in inland areas and compared with those of migrating wolves (Canis lupus L.).

RESULTS

A summary of den site locations (table 1) suggests that bears select coniferous forests or forests containing conifers to overwinter in. It became evident during the field work, especially in eastern Lapland and northern Finland, that brown bears had difficulties digging in the ground due to its stony consistency (Pulliainen 1974). The dens were covered by a thick layer of snow during the winter.

Table 1.--Location of brown bear den sites in Finland

Site	Number	Percent
Under roots of a conifer	11	26.8
Dug into an ant hill	11	26.8
Under a big boulder or between several boulders	9	22.0
Under the crown of a fallen conifer	3	7.3
Dug into the ground	3	7.3
Under the lower branches of a spruce	2	4.9
In a rock cave	2	4.9
Total	41	100.0

Food

Figure 1 shows the frequency with which major food items are found in the stomachs of the bears studied. The percentages of ungulate protein, ants, and other insects are conspicuously high from May through July. During this period, berries, roots, and other plant matter are of minor importance. Once the berries have ripened in August, they become important diet items. In the southern part of the study area, oats and other available cereals were similarly utilized by the bears.

Paper prepared for the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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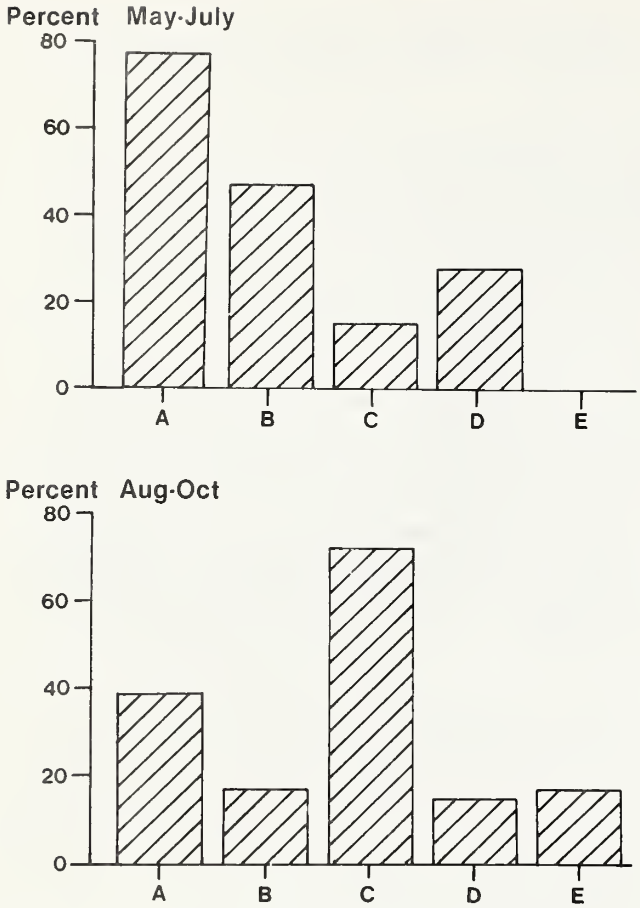

Figure 1.--Food of the brown bear from May to July (n = 47) and August to October (n = 47) according to stomach analyses. A = flesh of large mammals; B = ants, insects, and so on; C = berries (Vaccinium myrtillus, Empetrum nigrum, Rubus chamaemorus, and Oxycoccus quadripetalus); D = roots and other vegetable matter; and E = cereals (oats).

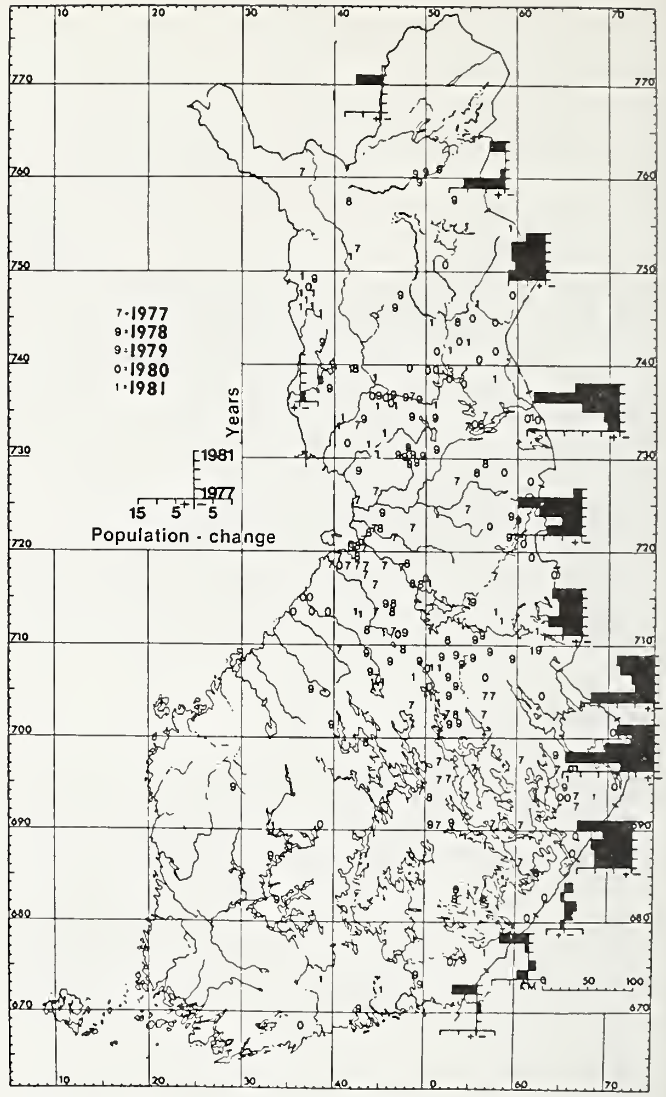

Figure 2.--Numbers of immigrating and emigrating brown bears along the Finnish border and one yearly occurrence of bears within the inland area. As reported by the Finnish Border Patrol Establishment, newspaper, and other public information sources.

During the first half of the summer, up to mid-July, the research team put out meat, fish, and other animal matter at a feeding site near the eastern frontier, which attracted a varying number of bears (for details, see Pulliainen and others 1984; Pulliainen 1984). At these feeding sites they observed a social hierarchy among bears, with older males being dominant (Pulliainen and others 1984).

Behavior of Recolonizing Bears

During the 1970's and early 1980's, bears immigrated into Finnish Northern Karelia, Kainuu, and Koillismaa, Finland, from the saturated Soviet Karelian population. Some individual bears moved into the inland areas of Finland, crossing the whole country from east to west (Pulliainen 1983) (fig. 2). There were several occasions when restless bears from wild uninhabited areas settled areas of eastern Finland. Later, the same individuals or others, if not actively disturbed, moved into the vicinity of southern coastal human settlements.

DISCUSSION

Bears consume their annual food needs during 6 months of the year, and thus the availability of these seasonal food resources plays a decisive role in their lives. The omnivorous nature of the grizzly helps it overcome the problem of varying food availability.

The brown bears in Finland experience seasonal extremes of food availability: in spring food is scarce but may be abundant in late summer. Food resources are generally more abundant in the southern part of the country.

Under difficult spring conditions cervid carcasses are assumed to be a highly desirable food item and a concentrated source of nutrition. Danilov (1983) studied the diet of bears beyond the eastern frontier of Finland and reported that ungulates constituted 4.6 percent of their diet in the Leningrad region, 13.1 percent in Karelia, and in the most northerly area of Kola Peninsula, 20 percent. Probably due to availability and possibly to food requirements (Landers and others 1980), animal matter was the most frequently occurring food from May through July in the present case (fig. 1). During the same period, bears may be attracted to artificial feeding sites (Pulliainen and others 1984; Pulliainen 1984).

As for habitat selection, bears tend to find their way in the first half of the summer to habitats where ungulates, their carcasses, or acceptable plants are available. The habitats where the snow first melts in the spring are important and offer food for both ungulates and bears. During the latter half of the summer, habitats producing berries such as Vaccinium myrtillus, Empetrum nigrum, Rubus chamaemorus, and Oxycoccus quadripetalus are essential. Vaccinium myrtillus grows mainly in forests; the other species occur in more or less open habitats. The last two species grow on marshy sites, many of which are now being drained in Finland and thus are becoming rare.

The seeking of shelter is another ecological factor that may govern habitat selection in the brown bear. Humans are the only significant predators on this species in Finland, and bears that have migrated into Finland from the east are moving from wild areas, where they are seldom, if ever, faced with human beings, into settled areas. Thus the rapid movement of bears from one area to another during the recent expansion from the east has been construed as an expression of their avoidance of humans. The immigration and emigration of bears along the Finnish border is summarized in figure 2. For each reporting area the horizontal axis represents the population change associated with the years indicated on the vertical axis. For the same period a yearly numerical code depicts the locations of inland bears as reported by newspapers and other public information services. On the other hand, those bears that have wandered to the southern coast area and stayed have settled in fairly populated areas (fig. 2). This observation indicates that they may become accustomed to human beings who do not harm them.

It has become evident during the recent recolonization of Finland by bears and wolves that there is a certain difference in habitat selection between these two species. Wolves use specific migration routes during their wanderings (Pulliainen 1980)--often ridges or other terrain where it is easy to move. This habit often leads them onto highways, where they are killed in traffic accidents; the bears move more or less directly through forested areas and only one has died in traffic accidents in Finland so far.

REFERENCES

Danilov, P. I. The brown bear (Ursus arctos L.) as a predator in the European taiga. Acta Zool. Fenn. 174: 159-160; 1983.

Landers, J. Larry; Hamilton, Robert J.; Johnson, A. Sydney; Marchinton, R. Larry. Foods and habitat of black bears in southeastern North Carolina. J. Wildl. Manage. 43: 143-153; 1980.

Pulliainen, Erkki. Suomen suurpedot. Helsinki: Tammi; 1974. 263 p.

Pulliainen, Erkki. The status, structure, and behavior of populations of the wolf (Canis l. lupus L.) along the Fenno-Soviet border. Ann. Zool. Fennici. 17: 107-112; 1980.

Pulliainen, Erkki. Behavior of an expanding population of the brown bear (Ursus arctos) in northern Europe. Z. f. Säugetierkunde. 48: 290-297; 1983.

Pulliainen, Erkki. Petoja ja ihmisiä. Helsinki: Tammi; 1984. 320 p.

Pulliainen, E.; Luukkonen, Y.; Hietajärvi, T. Formation of a dominance hierarchy among wild brown bears (Ursus arctos). Z. f. Säugetierkunde. 49: 58-59; 1984.

INDUSTRIAL AND AGRICULTURAL INCURSION INTO GRIZZLY BEAR HABITAT:

THE ALBERTA STORY

Brian L. Horejsi

ABSTRACT: Agriculture, logging, and oil and gas exploration and development have recently made rapid inroads into grizzly bear habitat in the South Wapiti region of Alberta. The present administration has not instituted compensatory management programs. Hunting, through vastly improved access, has affected the population of marked bears. Until there are major changes in the attitude and actions of elected governments and land management agencies, bear habitat will continue to shrink. Populations can be expected to decline in response, leading to insular populations centered in our national parks. Necessary changes in philosophy and management are listed.

INTRODUCTION

A recent article about grizzly bears (*Ursus arctos*) in the United States indicated that grizzly populations in Canada were secure (Turbak 1984). In fact, not all Canadian populations are secure. Grizzly populations in south and central Alberta are being disregarded by an increasingly antiwildlife provincial administration that has allowed intensive development pressures from three industries--agriculture, logging, and oil and gas exploration and development--without compensatory management. This paper presents illustrative data from an area roughly 40 km southwest of Grande Prairie, AB (fig. 1).

The study area is known as the South Wapiti. It is an area of extensive pine-spruce upland forests and aspen-shrub-conifer mixed forest in the lowlands. The South Wapiti ecosystem lies within two administrative land use zones--the green and yellow zones. This zoning, established in 1948 and at least partially based on land capabilities, was to define the limits to agricultural and residential development; the green zone being the area in which such developments were prohibited. In the yellow zone, agricultural and residential development was to be permitted provided the land was not required for conservation, forestry, recreation, or wildlife habitat. The study area lies entirely within the green zone, administered by the Alberta Forest Service, but is bordered on the immediate north by the yellow zone, administered by the Public Lands Division.

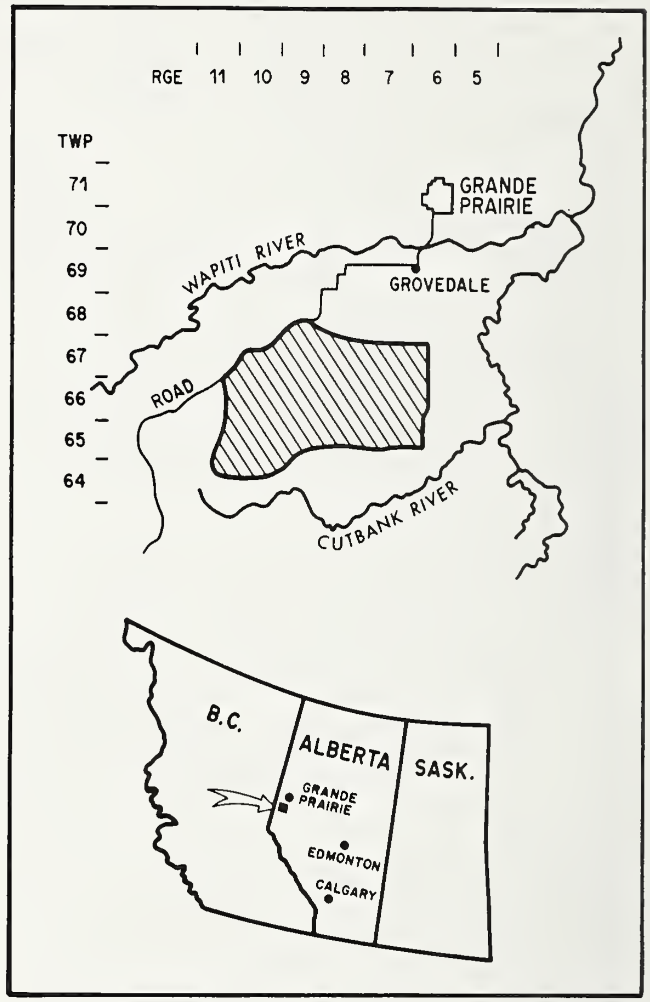

Figure 1.--Location of the South Wapiti study area.

In 1969 the provincial government signed a Forest Management Agreement (FMA) concerning lands in the study area. In 1978 an extensive and rich natural gas field was discovered underlying the area, and it is toward the South Wapiti that human habitation and agricultural activities are creeping. The impact of these three types of activity are herein addressed by documenting the changes that have occurred recently, presenting data on the marked grizzly bear population, and suggesting some remedies.

POLITICAL CLIMATE: A HABITAT PARAMETER

Although there exists a clear separation in conservation philosophy between most biologists and

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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the politicians and senior administrators they work for, the role of most biologists in Alberta is to facilitate the actions of specific interest groups. They can act, therefore, only within very narrow limits, those limits being set by elected members of government. These limits can only be broadened by public education, public participation, and public activism.

In Alberta the prospects for wildlife conservation are extremely limited. This is not a narrowly held view. In 1984 a questionnaire was circulated to 150 residents of Grande Prairie and area; of 80 respondents, 51 provided a yes or no answer to the question, do you think our politicians care what happens to grizzly bears? Eighty percent said no!

Alberta does not have the advantage of large tracts of federal land or an Endangered Species Act to encourage wise bear management. We do not have the exceptional wilderness system, with prospects for its expansion (Edwards 1985), found in the United States. A policy that provided limited protection for grizzly bear habitat, the East Slopes Policy of 1977 (Alberta Energy and Natural Resources 1977), has been struck down by a Revised East Slopes Policy (Alberta Energy and Natural Resources 1984a). The East Slopes consist of a narrow strip of foothill and mountainous public land on the western edge of Alberta on which most of the Province's grizzly bears are found. The philosophy of the present administration is evident from the thrust of the revised policy, which states that:

1. "Resources extraction objectives such as those of trapping, logging, domestic (stock) grazing, petroleum, natural gas, coal, and mineral exploration and development may be achieved" in critical wildlife zones.
2. "The sale of parcels of public land for permanent and seasonal residential use may be considered."
3. "To expand domestic livestock grazing opportunities on public lands" is an objective in the area that includes the South Wapiti.
4. Should anyone wish to use public land in an area or a way that is presently not permitted, a request for a zoning change can be made.

Before eliminating the East Slopes Policy as an instrument for wildlife and land conservation, the Lougheed administration proceeded with public hearings into the expansion of agricultural lands in Alberta. This thrust has been incorporated into Integrated Resource Management Plans (IMP), the vehicles through which the Revised East Slopes Policy will be implemented. Such a plan is the Sturgeon Lake-Puskwaskau East IMP (Alberta Energy and Natural Resources 1984b), which affects lands that border the South Wapiti ecosystem on the northeast. Under this plan there will be a net transfer of 190 sections of land from the semiprotected green zone to the development-oriented yellow zone. The report states that "about 210 sections (54 000 ha) of high quality (wildlife) habitat will be lost to agricultural development." In addition to these settlement-cultivation losses, alternative lands will have to be found for displaced grazing rights. Such lands will come from the public land-wildlife habitat pool, creating an impact far beyond the original development. Immediately north of the South Wapiti study area, where land is increasingly being transferred from public to private ownership, the "greatest limitation to substantial expansion" of agricultural activity is viewed as being the green zone boundary (South Peace Regional Planning Commission 1984).

The administration in Alberta has taken calculated steps to reduce the effectiveness of the Fish and Wildlife Division through staff reductions. In one district office where three people were present in 1980, there was only one in 1984. That office, in a 15-month period in 1980-81, received 609 applications for construction of oil and gas leases, access roads, and pipelines. During an 11-month period in 1984-85 the number of applications received was 528. On a monthly basis the number of applications to be reviewed rose from 15 to 48 for the single person present. Wildlife considerations were obviously much more superficially treated in 1984 than in 1981.

Wildlife research has also suffered in Alberta; three studies of grizzly bear populations under way in 1981 on Provincial lands had all been terminated by April 1985. Two were terminated prematurely by the Provincial government, with no plans for data analysis or reports.

RESULTS AND DISCUSSION

Agricultural Activity

In 1983 the Provincial government announced a plan for, and held hearings concerning, an expected million-square-kilometer expansion of the yellow zone. Such an ambitious scheme presents an extremely serious threat to the South Wapiti grizzly bear population. Even before the results of the hearings allow or deny a chance to alter green zone-yellow zone boundaries, there have been significant land use changes within the existing zones--changes already harmful to the grizzly.

The yellow zone on the northern edge of the study area (Township 69 and north) was originally all public land and all grizzly bear range. Agriculture has been identified as a factor impacting wildlife lands historically (Brown 1985; McCrory and Herrero 1982), and such is the case in the Grovedale area (fig. 1), where agriculture began in the 1930's. It is somewhat surprising, though, that the majority of agricultural expansion occurred not a long time ago but within the last 15 years. The transfer of grizzly habitat to private ownership skyrocketed in the 1970's, when 48 percent of all the land ever to come into private ownership in the study area was lost to government control (fig. 2) and, coincidentally, to grizzly bears. With those rapid changes in land control came a 213 percent increase in human population; where 258 people resided in 1961, 854 lived in 1982 (South Peace Regional Planning Commission 1984).

In the mid-1960's an even more serious threat to grizzly bears developed. Two grazing leases were established in the green zone, one in the heart of the study area and one to the northeast.

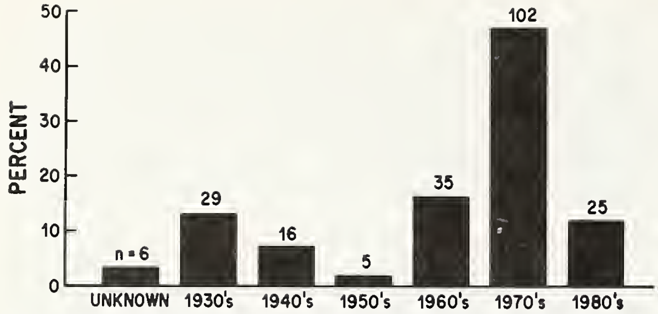

Figure 2.--Periods during which 218 quarter sections of land (former grizzly bear habitat) transferred from crown (government) to private ownership in Ranges 7, 8, and 9 east of Grovedale and south of the Wapiti River. Data include part of 1984.

The Stony Creek lease was issued in 1966 and covered 735 ha in the middle of grizzly bear habitat, an area where no cattle had grazed before 1966. The lease was expanded to cover 1 093 ha in 1970 and remains roughly that size in 1985. The leasee has made application to improve the range, through vegetation modification, and is to fence the area. In 1984 the Alberta Forest Service attempted to cancel the lease by offering three alternate areas outside of grizzly bear range, but the leasee has refused to move. The Forest Service has been forced to relent.

The fate of the wolf (*Canis lupus*) in the lease area can be used to predict the grizzly bear's future. As a consequence of the leasee's depredation problems, real or otherwise, 29 wolves were removed from the lease area between 1974 and 1977. Grizzly bears, too, will kill livestock, whether sheep or cattle (Knight and Judd 1983; Jorgensen 1983). Even though Knight and Judd believe cattle and grizzly bears can coexist "if cattle owners are willing to absorb losses," such tolerance is rare (McCrory and Herrero 1982) and cannot be relied upon.

The two-pronged agricultural threat, first of grazing leases and the subsequent demand for stock protection, and second, the clearing of land and permanent inhabitation of such areas, is a far more serious threat to grizzly bear populations than is the threat of logging or oil and gas exploration. Agricultural development is permanent; people gain control and ownership of the land. They subsequently become protective of their land and property, including stock, and usually want the area biologically sanitized, meaning no bears. This leads to a decline in grizzly bear range and range quality, and then, when private ownership of land is extensive, the disappearance of bears ensues (Elgmork 1976).

Logging Activity

In 1969 the Provincial government signed a forest management agreement with Proctor and Gamble Cellulose Ltd. (P&G) that gave the company exclusive rights to all the timber on an area of 15 285 km². This immense area includes the study area and most of the range of grizzly bears that occupy the study area.

The rights granted to P&G are largely equivalent to those of private ownership. The Alberta Forest Service administers the agreement, with their responsibility being primarily to ensure that P&G removes all timber from the area regardless of the quality of that product. This narrow interpretation forces P&G to harvest areas uneconomical or unattractive to it when such areas could best be used as islands of wildlife habitat.

The forest management agreement in question has no provision for wildlife management input. To incorporate its concerns, the Fish and Wildlife Division can at best hope that P&G and the Forest Service will grant them some concessions. In reality, the Forest Service often acts as a consultant for the company, assisting their interests over those of wildlife and the public.

The management agreement comes up for review every 5 years, and by continually expressing concerns and making inquiries, fish and wildlife biologists at the field level have managed to comment on P&G's timber harvest plans. They have also begun direct negotiations with the company. It has proven impossible, however, to appreciably alter logging activities or forest management area boundaries so as to protect sizable tracts of habitat for grizzly bears and other species.

Although logging has occurred in much of the South Wapiti ecosystem, it has only recently begun to encroach on the study area (fig. 3.); the majority of cuts within the area proper have taken place

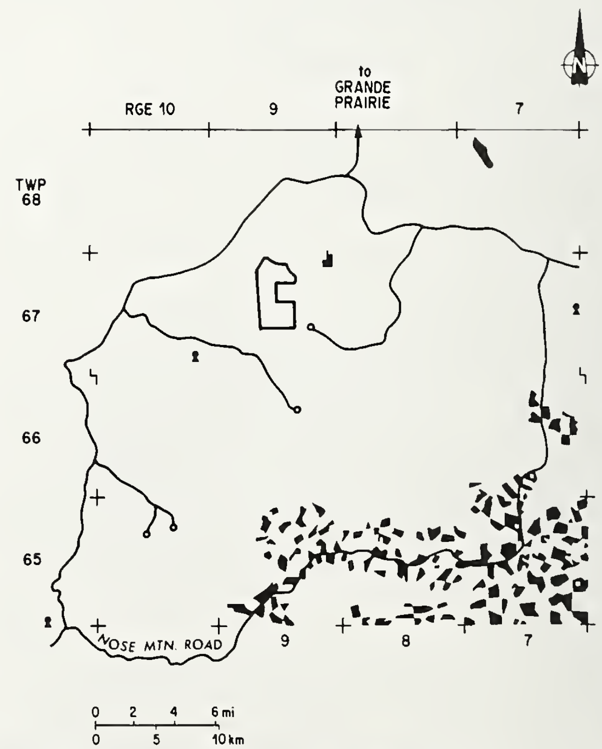

Figure 3.--The location of clearcuts (■) in the South Wapiti area.

since 1983. Four townships that overlap the southeast corner of the study area have had 781, 1 645, 2 185, and 3 629 ha logged, representing 8, 18, 23, and 39 percent respectively, of the area of those townships.

On the positive side, clearcut size declined from the 1970's to the 1980's. The mean size of clearcuts in the 1970's was 59 ha (n= 28), but this has been reduced to a mean of 46 ha (n= 48) in the 1980's ($p \leq 0.02$), a trend that should be encouraged and for which regional biologists and P&G should be congratulated.

As ominous as this extensive clearcutting may seem, there is still less cause for concern about logging than about agriculture. On the basis of my work, the most harmful aspect of clearcutting in the South Wapiti is the provision of access. Excepting main haul roads, the situation is short term, as the roads deteriorate quickly and are allowed to do so. Unlike agriculture, the human presence during logging is short term--the trees are taken, and the area can be abandoned, excluding regeneration activity. Road closures and reclamation would further improve this situation.

It is even possible that, in areas of extensive and dense forest cover, limited and judicious opening of the canopy may prove beneficial to the grizzly bear. Preliminary indications are that such areas will be used by grizzlies *if* human disturbance is absent (Jonkel 1982; Zager and others 1983). Our data (Horejsi and Hornbeck 1984) indicate likewise--that bears will use clearcuts, in the absence of human activity, particularly when regeneration is high enough to obscure a bear. The question remains unanswered, however, as to how the grizzly bear in the South Wapiti would do in a habitat liberally dissected by clearcuts, versus how it would do in the still largely uncut forest.

If competition exists between black bears and grizzly bears, then the removal of forest cover may confer a competitive advantage on grizzly bears (Jonkel 1985). In the South Wapiti area, where both bears are common, clearcutting in the absence of other influences may tip the odds in favor of the grizzly bear. In such a situation, management emphasis must be placed on the control of access and human activity, including hunting.

Oil and Gas Activity

The oil and gas industry is a major contributor to the economy of Alberta. An average of over 5,000 holes per year are drilled in the Province.

Exploration for gas and oil in the South Wapiti began to flourish in 1978 (fig. 4). Drilling required access roads, and during the boom of 1978 through 1981, the yearly pattern of kilometers of road built (fig. 5) mirrored almost exactly the pattern of the number of wells drilled. Grizzly habitat quality, particularly the security aspect of habitat, changed in response. Figure 6 shows the South Wapiti as a relative wilderness in 1969, in stark contrast to figure 7, which shows the

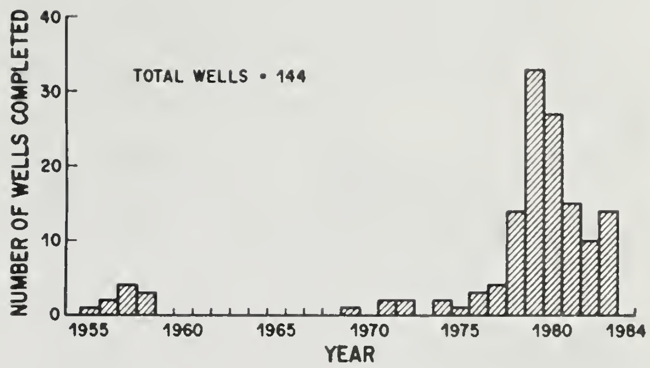

Figure 4.--The number of wells drilled in the study area (Townships 65-68, Ranges 7-11, W6M), 1955 to 1984.

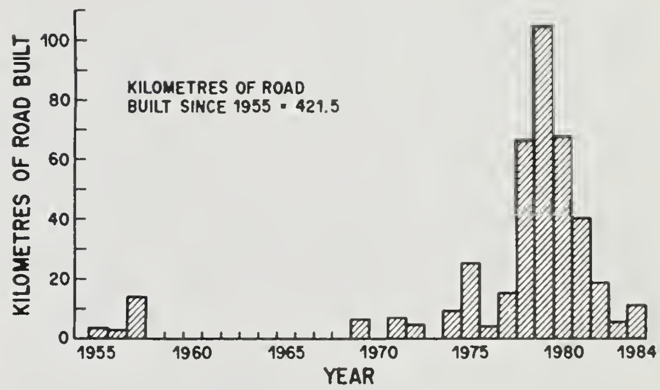

Figure 5.--Kilometers of road built in the course of oil and gas exploration in the South Wapiti (Townships 65-68, Ranges 7-11, W6M), 1955 to 1984.

massive dissection of the area by roads built for resource exploration and extraction.

Few areas escaped the impact of road building and well drilling (table 1). This even distribution of activities came about as a consequence of government policy that provides tax incentives when a gas well is drilled at least 4.8 km away from any existing well. Such policy was designed, with no regard for the wildlife resource, to force exploration companies to expand their zone of exploration, and it has been very successful in achieving that end.

As a consequence of legally defined well-spacing requirements, drilling for gas will have less impact on bears and bear habitat than will drilling for oil. It is technically easier to "drain" a gas field than an oil field; thus gas wells are allowed at a density of one per square mile, whereas oil wells may be permitted at a density as great as 16 per square mile. Such a situation occurs in Township 67 Range 8 (table 1; see also fig. 7), where a shallow oil field is being exploited by Canada's national oil and gas company, Petro Canada.

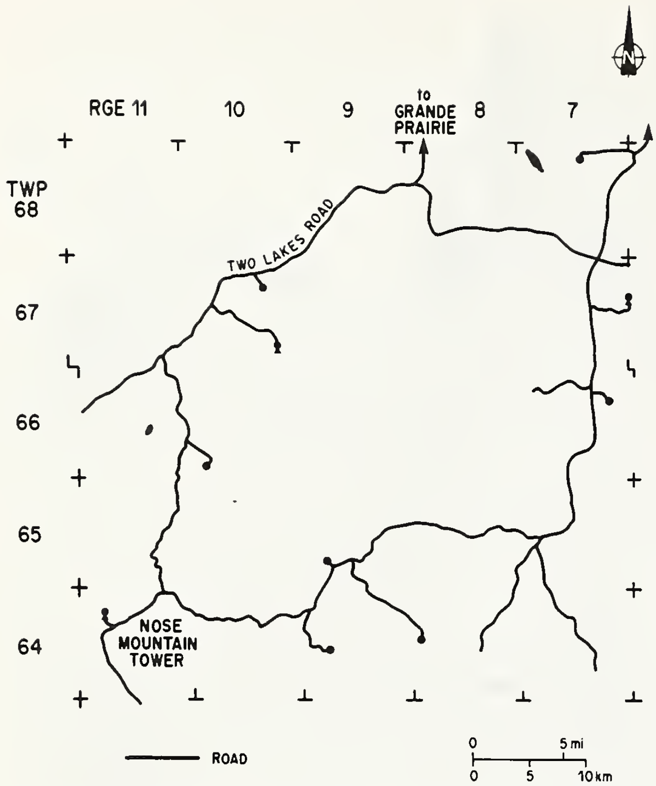

Figure 6.--The South Wapiti area showing roads present at the end of 1969.

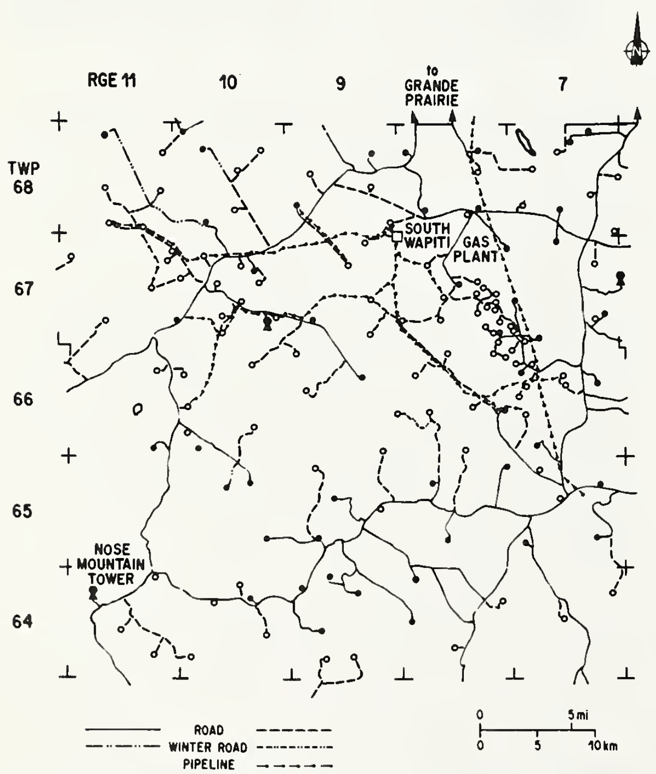

Figure 7.--The South Wapiti area showing roads and pipelines present as of January 1985.

Table 1.--Distribution of wells drilled in the South Wapiti study area (Townships 64-68, Ranges 7-11 W6M) between 1955 and January 1985

Township	Range 11	10	9	8	7	Total
68	6	6	5	6	10	33
67	5	10	5	18	9	47
66	2	5	5	8	10	30
65	0	3	4	3	5	15
64	3	4	6	4	2	19
Total	16	28	25	39	36	144

That area has experienced the most intense exploration-development activity in the South Wapiti ecosystem. Petro Canada, whose motto is "for the good of Canadians," has reaped immense benefits from the underground resource but has done nothing to safeguard bear habitat. By their nonparticipation in this grizzly bear study and their refusal of the information generated, they have consciously chosen not to consider the welfare of the grizzly bear population in their drilling and road-building plans.

Drilling activity likely leads to the exclusion of certain bears from certain habitats, the average well in the South Wapiti taking 59 days (n= 144) to drill. The extent of this exclusion, and its impact on a bear, is likely to vary according to the philosophy and actions of the companies involved, the behavior of the people in the field, the intensity of drilling, the nature of the habitat, and the individual bear's behavior.

What we are faced with during the life of a gas or oil field is maintaining a grizzly population at a viable level so that, even if numbers are somewhat reduced, there are enough individuals surviving to permit the population to recover should it become free of the demands of resource development. This is possible if access and hunting are restricted, but the likelihood of such restrictions is the crux of the problem. There is an official unwillingness to control access and hunting. The onus is on government, not industry, to do that. Industry can greatly downgrade road standards to winter road status; well head facilities are increasingly being remotely operated by computer; servicing can be done by helicopter. Such changes in operating procedures can reduce access and impacts on wildlife populations, but the onus is on politicians to require the changes. In this respect, Alberta has been negligent.

THE GRIZZLY BEAR POPULATION

This brief discussion of the grizzly bear population in the South Wapiti is restricted to the captured population and available statistics on legal and illegal kills. In 4 years, eight of the 35 bears captured have been killed (fig. 8), and two other bears are unaccounted for.

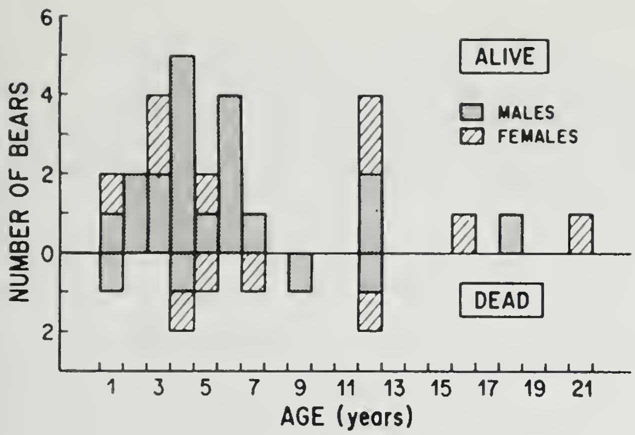

Figure 8.--Age distribution of captured grizzly bears and their young in the South Wapiti area as of November 1984.

At a minimum, this represents an annual mortality rate of 6 percent. More significant is the following: 50 percent of the bears killed were females. Four of the nine females 4 years of age or older have died, an annual mortality rate of 11 percent. The importance of survival among adult females cannot be overstated (Knight and Eberhardt 1984), and it is likely that the high level of mortality among this class of animal in the South Wapiti, if representative of the population at large, exceeds that which would permit the existence of a stable population.

The number of legally registered grizzly bear kills in and around the study area during a recent 6-year period is given in figure 9.

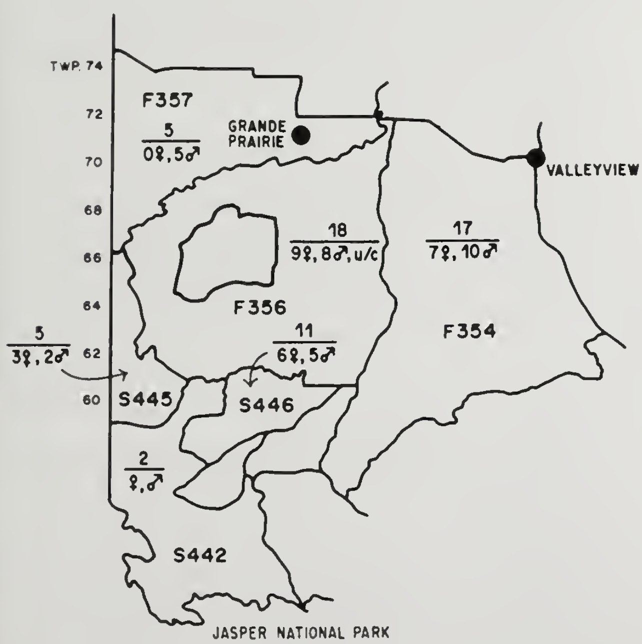

Figure 9.--The number (above line) and sex (below line) of grizzly bears killed in the South Wapiti area, by wildlife management unit (prefix F or S), 1979 to 1984.

Telemetry data (Horejsi and Hornbeck 1984) indicate that the bears caught in the study area range into wildlife management units (WMU's) F357, F356, S445, S442, and S446, as well as adjacent British Columbia. The registered kill of grizzly bears from the South Wapiti populations is 41 animals in 6 years. Nineteen of those bears have been female.

Data from marked animals indicate that three of eight kills (38 percent) were illegal. With this in mind, the legally registered kill can be reexamined. Recognizing that it includes five known illegal kills (three mentioned above, plus at least two others), total human-caused losses can conservatively be estimated at 49 bears (.38 x [41-5]). Illegal kill is, however, likely to be even greater than 38 percent of the legal kill. In addition, the extent of natural mortality is unknown. Total losses to the population, therefore, unquestionably exceed known mortality.

In addition to the effect of improved access on legal and illegal killing of grizzly bears, industrial and agricultural activity creates what could be defined as a deliberate conflict between humans and bears. Among these conflicts, agriculture has the greatest impact on grizzly bears (table 2). In Alberta, it is legal for a landowner or leasee to kill any black bear on land under the individual's control; neither permission nor reporting of kills is required. Given the difficulty understaffed wildlife officers have in responding to complaints, there seems no question that the number of bears reported (table 2) is but a fraction, perhaps one-third to one-half, of those actually removed, all but a few of which are killed.

Table 2.--Number of grizzly and black bears removed from the South Wapiti area (Townships 61-69, Ranges 4-13 W6M) as a consequence of five kinds of human activities, 1977 to 1984. (All removals listed were management actions.[1])

Year	Activity											
	Agri-culture		Logging		Oil and Gas		Admin./Subdiv.		Recre-ation[2]		Total	
	B[3]	G	B	G	B	G	B	G	B	G	B	G
1977	9		18	1	20		3		5		55	1
1978	4	1	4	1	3				4		15	2
1979	1	1	2		19	[4]1	1		6		29	2
1980	5		6		38		3			1	52	1
1981	1	[5]3	5		5						11	3
1982			4		3						7	0
1983	9		1				1		2		13	0
1984	1		1		2		1		1		6	0
Total	30	5	41	2	90	1	9	0	18	1	188	9

[1]Source: Alberta Fish and Wildlife Division occurrence records.
[2]Management actions associated with recreational facilities.
[3]B = black bear; G = grizzly bear.
[4]Cub sent to zoo.
[5]Female and two cubs relocated 197 km distant.

Has grizzly mortality increased since the increase in accessibility, or are there more bears? The Province of Alberta, in a political analysis of the status of the grizzly, stated that populations declined in the 1960's but have increased since the 1970's (Alberta Energy and Natural Resources 1984c). Unfortunately, no field study of any grizzly bear population on Provincial lands had ever been done before 1974; thus the analysis cannot be substantiated.

The South Wapiti study area is in WMU F356. Access to WMU's F354 and S446 increased dramatically, at the same time and for the same reasons, as it did in F356. In contrast to these areas, F357 is a largely agricultural area with relatively undeveloped perimeters that has seen no significant changes in access for at least 10 years. It is not coincidence that the number of registered grizzly bear kills has about doubled in those management units where access has greatly improved during the last 6 years (fig. 10). Yet the heart of the problem is not simply access but, more precisely, the lack of restrictions on carrying guns and hunting.

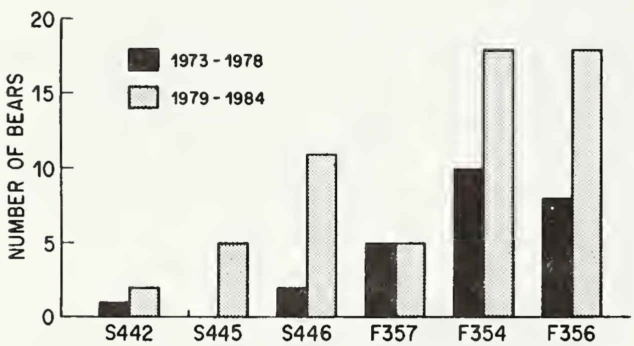

Figure 10.--Number of grizzly bear kills registered during two 6-year periods in Wildlife Management Units in the South Wapiti area.

REMOVING THE THREAT TO GRIZZLY BEAR POPULATIONS

Actions that would help conserve grizzly bear populations can be placed in two categories: long-term solutions and immediate or temporary solutions.

Long-term solutions are, in reality, the only solutions. They include:

1. The establishment, on Provincial land, of an extensive wildlife refuge and wilderness preservation system similar to that found in the United States of America.
2. The establishment of administrative areas where oil and gas exploration and timber harvesting continue but the carrying of weapons is severely restricted and hunting is not permitted.
3. A major change in the mandate of the Alberta Forest Service. Their advocacy role on behalf of forest, oil and gas, and grazing industries must be replaced with the recognition that wildlife values equal, or may exceed, those of other resources. Becoming accountable to all of the people of Alberta will require a massive change of attitude by agency professionals.
4. The development of a political will that recognizes the social, recreational, and ecological values of grizzly bears and thus their need for security and habitat.

Immediate or temporary solutions will extend the life of existing bear populations and will lead to long-term solutions. They include:

1. The development of citizen groups that fervently pursue wildlife conservation through political and public education channels with the assistance of government funding.
2. The cessation of crown land sales.
3. The removal of rights-of-ownership from leased land holders.
4. Government uniformity in the demands made of, and expectations placed upon, industry. Guidelines protecting wildlife and wildlife habitat should be legislated and enforced.
5. A surcharge placed on each exploration and development project on crown land, leases included, amounting to 10 percent of the cost of each program between $50,000 and $5,000,000 (scaled back when larger sums are involved). This money would go into a fund for long-term wildlife monitoring and research programs, with major emphasis on the area affected by exploration. Such a fund would be collected and held by a foundation with funds assigned by a review board of industry biologists, consulting biologists, academics, the public, and government biologists.
6. Development of an information and education section in the Fish and Wildlife Division.
7. A major effort to inform individuals who graze cattle on crown land that theirs is a privileged position and that privately owned cattle do not take precedence over publicly owned grizzly bears.
8. Prompt action by the Forest Service, in cooperation with the Fish and Wildlife Division, to completely restrict access in key nonwilderness areas and on all but designated routes in other nonwilderness areas, both during and outside of hunting seasons.
9. Where access for resource extraction is permitted, all but main roads should be kept to winter road standards.
10. Strict regulations and enforcement regarding garbage management should be applied in resource development areas.
11. The elimination of fall grizzly bear hunting in all areas where motorized travel is permitted.
12. Establishment of a kill quota, not to exceed 5 percent of the population, that incorporates legal and illegal kills, whether sport hunting or management related. All grizzly bear hunting licenses should be chosen by draw.
13. The elimination of hunting in at least one out of every three wildlife management units, possibly on a rotating basis.

SUMMATION

Agriculture, logging, and oil and gas exploration have dramatically changed grizzly bear habitat in the South Wapiti. The impact of agriculture, excepting grazing, can be mitigated only in special cases. The impacts of logging and oil and gas activities manifest themselves primarily through access and subsequent hunting pressure. At this time, government has not compensated for these changes with improved management.

Most resource companies are not knowledgeable about wildlife and therefore may be indifferent, if not opposed, to wildlife conservation measures. There are exceptions among corporations, but our present system does not reward them for their exemplary conduct. Their voluntary help and understanding are important and should be recognized. Implementation of the short-term measures previously itemized will slow grizzly habitat and population losses, and they therefore require prompt action. It is not the responsibility of resource companies to make major decisions regarding the management of wildlife resources, but it is their responsibility to demonstrate wise corporate stewardship of wildlife resources by conducting their operations with the interests of that resource in mind and by providing information about the interaction of that resource with company operations.

On the other hand, it is the responsibility of elected government to maintain grizzly bear populations. The government of Alberta has not fully met this responsibility. The absence of compensating management programs for wildlife in today's resource extraction arenas, where there is almost no control of access and little control of hunting, is evidence of its default. Elected and senior appointed officials in Alberta have demonstrated a low regard for public land and wildlife resources.

ACKNOWLEDGMENTS

I particularly wish to recognize the very capable assistance of my colleague, Garry E. Hornbeck. I thank Drs. C. Jonkel and P. Zager for their constructive reviews and I wish to thank Canadian Hunter Exploration Ltd., of Calgary, AB, for funding the grizzly bear field work.

REFERENCES

Alberta Energy and Natural Resources. A policy for resource management of the eastern slopes. Edmonton, AB. 1977. 19 p.

Alberta Energy and Natural Resources. A policy for resource management of the eastern slopes revised 1984. Edmonton, AB. ENR No. T/38. 1984a. 20 p.

Alberta Energy and Natural Resources. Integrated resource plan; Sturgeon Lake-Puskwaskau East sub-regional plan. Edmonton, AB. Tech. Rep. No. T/1, No. 14. 1984b. 139 p.

Alberta Energy and Natural Resources. Status of the fish and wildlife resource in Alberta. Edmonton, AB. Fish and Wildlife Division. ENR No. 1/87. 1984c. 123 p.

Aune, Keith; Stiver, Tom; Madel, Mike. Rocky Mountain Front grizzly bear monitoring and investigation. Helena MT: Montana Department Fish, Wildlife and Parks; 1984. 239 p.

Brown, D. E. The grizzly in the Southwest; documentary of an extinction. Norman, OK: University of Oklahoma Press; 1985. 274 p. + appendices.

Cheek, R. Bears don't always look the same. Tobacco Valley News, Eureka, MT. 1983 September 8.

Edwards, Mike. Battle for a bigger Bob. National Geographic. 167(5): 690-692; 1985.

Elgmork, Kare. A remnant brown bear population in southern Norway and problems of its conservation. International Conference on Bear Research and Management. 3: 281-297; 1976.

Horejsi, Brian; Hornbeck, Garry. South Wapiti Grizzly bear study. Unpublished data, on file at: Western Wildlife Environments Consulting Ltd., Calgary, AB. 1984.

Jonkel, Charles. The border grizzly. Western Wildlands. 8(1); 32-36; 1982.

Jonkel, Charles. Personal communication. 1985 April 3. Missoula, MT.

Jorgensen, Carole. Bear-sheep interactions, Targhee National Forest. International Conference on Bear Research and Management. 5: 191-200; 1983.

Knight, Richard; Judd, Steven. Grizzly bears that kill livestock. International Conference on Bear Research and Management. 5: 186-190; 1983.

Knight, Richard; Eberhardt, L. L. Projected future abundance of the Yellowstone grizzly bear. Journal of Wildlife Management. 48(4): 1434-1438; 1984.

McCrory, Wayne; Herrero, Steve. A review of historical status of the Grizzly bear in Kananaskis Country, Alberta. BIOS Environmental Research and Planning Associates Ltd. for Alberta Fish and Wildlife Division, Calgary, AB. 1982. 123 p.

South Peace Regional Planning Commission. Grovedale Area Planning Study. Grande Prairie, AB. 1984. 84 p.

Turbak, G. Lord of the mountain. Equinox. 18: 63-67; 1984.

Zager, Peter; Jonkel, Charles; Habeck, James. Logging and wildlife influence on grizzly bear habitat in northwestern Montana. International Conference on Bear Research and Management. 2: 124-132; 1983.

GRIZZLY BEAR HABITAT RESEARCH NEEDS IN THE BORDER GRIZZLY AREA

Charles J. Jonkel and David Hadden

ABSTRACT: Needed grizzly bear habitat research has been seriously delayed. The required studies fall into three main categories: further studies in habitat use and habitat relationships; studies that develop and refine existing and additional systems for classifying, mapping, and monitoring existing habitat and habitat changes; new studies on special vegetation topics such as habitat improvement techniques, the growth and development of key bear food plants, disturbance impacts, the development relationships and growth dynamics of key bear food species that thrive on disturbed sites; and the nutritional levels and nutrient extraction of key grizzly foods. Short descriptions, justifications, and the status of needed studies are given; a priority ranking is presented for consideration.

INTRODUCTION

Habitat management is the main key to managing and preserving any wildlife species. Without an adequate data base on habitat relative to individual species, and without the application of habitat management principles relative to that data base, the management of a target wildlife species is impossible. Habitat loss ultimately leads to species loss. Without an adequate habitat, subtle and direct impacts combine to cause the death of individual animals, and reproduction fails to balance death rates. The direct causes are relatively easy to measure and comprehend; indirect losses because of stress, seasonal inadequacy, a degraded nutritional level, behavioral changes, low genetic or behavioral plasticity relative to habitat change, and interspecies competition are difficult to detect and measure. For example, losses of individual grizzly bears (Ursus arctos horribilis Ord) that die from indirect or obscure causes are just as serious as are losses from bear-people conflicts or hunting.

The grizzly requires large ranges to meet its foraging, denning, reproductive, and behavioral needs. The sizes of grizzly bear ranges vary by habitat adequacy (Pearson 1975; Craighead 1976; Jonkel 1982), which in turn varies regionally. Many of the regional variations in habitat adequacy are based on naturally occurring land capabilities; other variations are caused by human activities and change constantly. Habitat management, therefore, must vary regionally, depends upon regional data bases, and must keep abreast of habitat quality changes. To clearly identify regional research needs and guide regional management, one must look at what circumstances exist, identify what we do not know, and set priorities based on management needs.

Management needs are the driving force for research needs, but unfortunately they are greatly influenced by such things as short-term goals and crises, political influences, budget cuts, interagency disputes, and a failure to apply existing data bases. As a result, research direction is often unclear and misdirected, long-term research needs are delayed or interrupted, and effective research vehicles are dismantled or hampered in their function. Grizzly bear habitat research is particularly vulnerable to such upsets because of the high profiles of grizzly research and management and because grizzly bears, grizzly bear research, and grizzly bear management obstruct resource exploitation and require care in resource development. Because grizzlies are long lived, have large range and nutritional needs, and are difficult animals to study, the entire research process suffers excruciating delays, and management gets ahead of research. Because the grizzly has considerable economic and political impacts, the research process is easily subverted and misused. Both the delays and interference in long-term research and the subversion of the research process must cease if grizzly management is to proceed in an orderly manner. A return to sanity in grizzly habitat research is essential to preserve the bear, but that does not ensure that a return to sanity is likely.

The complex of considerations previously cited, plus subjective estimates based on long-term, future outlooks for the grizzly, the status of other bear species' habitats, the political realities of grizzly bear management, and even the impending world-wide human population-resource depletion crunch, must be considered in identifying research needs and priorities. The following list of priorities and justifications provides needed vision; it may help determine long-range research goals for the Border Grizzly Area as well.

NEEDED RESEARCH BY PRIORITY

Disturbed Site Vegetation Studies

According to Border Grizzly Area (BGA) food habits studies (Mace and Jonkel 1983), grizzly bears consume nearly 200 separate plants in the BGA. Only about 30 of the plants are significant food

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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sources in any local area, however, and a high percentage of that 30 are "lovers of disturbed sites." Plant species such as glacier lily (Erythronium spp.), Claytonia spp., and Carex spp. proliferate on avalanche chutes; cow parsnip (Heracleum lanatum), Equisetum spp., and Hedysarum spp. are found on creek bottom and river bank or flood plain disturbed sites; and Vaccinium spp. and Amelanchier alnifolia grow abundantly on burns; Hedysarum spp., Lomatium spp., and Erythronium spp. respond to the mechanical disturbance of bears digging for roots and corms; species such as dandelion (Taraxacum spp.), Trifolium spp. (clover), and Angelica spp. readily respond to human mechanical disturbance.

Most impacts relative to grizzly management and survival result from losses caused by excessive habitat disturbance. For example, habitat disturbances such as clearing for agricultural use, subdivisions, or water impoundment cause permanent loss.

However, shorter term disturbances such as timber harvest, road construction, postlogging treatments, revegetation programs, and controlled burns also disturb grizzly bear habitat, but contrary to popular belief, many of the key bear foods can respond favorably to these lesser, human-caused disturbances, provided the disturbance is properly designed. If cover or isolation stay intact, properly designed development need not seriously damage grizzly bear habitat quality. However, the mechanisms for promoting grizzly bear use and favorable growth responses from the key bear food "lovers of disturbed sites" after human-caused disturbances remains poorly studied. Because human-caused impacts will increase, and may either harm or aid bears, this area of research must have the highest priority.

Habitat Improvement Research

Many grizzly bear habitats were inadvertently damaged through past development programs such as the massive clearcutting and 100 percent scarification logging operations of the 1950's and 1960's. Recovery as grizzly habitat or as timber-producing sites has not progressed on many sites. Certain current logging designs and developments also do not respond as expected, adding grizzly bear habitat losses. Other disturbed sites do recover but respond slowly. In all cases, the recovery of such sites could be greatly accelerated if better cutting and post-logging treatment, plus grizzly bear habitat improvement techniques were available. Moreover, wildlife habitat improvement funds are available from timber sales, but our knowledge of how to improve grizzly bear habitat is nearly zero. Long-term, quantitative studies are essential; current habitat improvement study efforts by Ranger District staffs are well intentioned but are short-term and consequently will provide inadequate or erroneous data bases. Considering the enormous additional disturbance impacts to grizzly habitat that are inevitable in the near future as human populations continue to expand rapidly, methods for designing disturbances, improving disturbed sites, and accelerating habitat recovery through the propagation of bear foods and increasing berry or tuber production or other means should be the second highest BGA research priority.

High-Density Grizzly Complexes

Certain areas of occupied grizzly bear habitat offer optimal habitat quality to which grizzly bears readily respond. All elements of the habitat must be intact, such as a superabundance of food within a high diversity of bear food species so that some type of food is available during all successional seasonal stages. Adequate cover or isolation must also be available, and the local bears must make behavioral adaptations if they are to use the site. In such cases, bears in the BGA reach densities as high as one bear/km^2 (Jonkel 1982). Under such circumstances, we have found as many as 40 grizzlies seasonally occupying areas the size of a single grizzly bear home range in the North Fork of the Flathead River. Such high-density areas are known for the East Front, the South and North Forks of the Flathead River, and the Mission Valley.

Management focus obviously should be centered on such high-use, high-density areas. Habitat research emphasis spread equally throughout occupied habitat (the current approach), including areas where the grizzly density may be as low as one bear per several hundred square kilometers, is not logical. Intensive management focus on the high-density sites is imperative; research data bases should be obtained with equal intensity. Careful management of such high-density areas is essential to maintain both habitat and grizzlies; this area of research should rank third in importance for the BGA.

Special Vegetation Studies

Certain key bear food species such as Heracleum lanatum, Claytonia spp., or Lomatium spp. are well-known plants, but their ecological relationships are not clearly understood. They are of little commercial value and are not significantly important to wild or tame ungulates. Consequently, we know little of their growth dynamics, food production, regeneration-reproduction, site preference, and so on. Some such plant species are enormously important to the grizzly, and they deserve intensive research emphasis. Vegetation studies are inexpensive, and some can be short-term. Having data bases on these species is essential before grizzly bear habitat components, bear movements, habitat use, and so on can be adequately analyzed. This area of research should be ranked fourth for the BGA.

Private Land Management Problems

Sixty-three percent of the occupied BGA south of Canada is under U.S. Department of Agriculture, Forest Service, jurisdiction. It follows that lands administered by the Forest Service should

receive a major research and management effort; however, many high-density grizzly complexes are on low elevational sites, often in private, local, corporation, or Indian ownership. These ownerships often have high seasonal densities of grizzlies; critical spring feeding sites and travel corridors are often on them. Bear-people conflicts, too, are centered on such ownerships; law enforcement is essentially impossible on the large blocks of private land; multiple jurisdictions prevail; the U.S. Endangered Species Act of 1973 does not apply directly to habitat; and the implementation of applicable laws occurs indifferently. Moreover, the responsible county, tribal, and soil conservation district governments have almost no motivation or expertise in land or grizzly management and research; most local governments actively follow directions counter to grizzly bear habitat management. Consequently, although the total habitat outside the jurisdiction of government agencies is low, these low-elevational areas are extremely crucial to grizzly survival. Perhaps up to 50 or 60 percent of our grizzly and grizzly habitat management problems occur on these ownerships, even though less than 20 percent of the occupied habitat is involved. It follows directly that research on management methodology is extremely crucial relative to this level of ownership and jurisdiction. Among long-range management goals, this area of research should rank at least fifth.

Grizzly Bear Habitat Use

How grizzlies use their local habitats is essential information for local management program implementation. Certain data bases and data sets can be extrapolated to new areas; many data sets cannot be extrapolated except on a temporary basis. Habitat use patterns change locally as impacts are introduced and altered or as the grizzly's relationships to black bears (Ursus americanus) and humans change. Local bears adapt to their local habitat; habitat use patterns evolve that are unique to that local area and are preserved through "cultural inheritance" passed on by mothers to young. It follows, therefore, that habitat use studies must be repeated locally wherever land use is intensified or altered significantly. Habitat use patterns by the local bears, together with locally designed habitat management, is the ultimate determinant in the survival of local populations. Many local area studies have been completed and some areas are being managed adequately using extrapolated data, but throughout the BGA this research topic is of high importance--at least a rank of sixth and higher in local areas.

Combined Grizzly Bear, Black Bear, and Human Habitat Interactions

Gross population comparisons indicate that grizzly bear habitat can be occupied by grizzlies alone or occupied by a lower number of grizzlies living in a state of habitat competition with black bears and humans (Jonkel and Carriles 1985). Although black bears, humans, and grizzlies can successfully occupy a unit of habitat simultaneously, under many circumstances a population increase by any of the three may affect the possible density level of the other two. Additionally, humans, together with either of the two bear species, can inhibit occupation by or population growth of the other species: if a black bear population is high, the adult male black bears may effectively inhibit the immigration or survival of subadult grizzlies; a high grizzly density apparently can inhibit or sometimes replace a local black bear population. Exact niche differences no doubt exist for people and the two bear species, but when a factor such as nutritional stress increases, the impact of people on bear density must increase. Further, the local stratification or segregation of black and grizzly populations has been noted in the North and South Forks of the Flathead River, in Alaska, and possibly in the Cabinet Mountains and in Yellowstone National Park (Jonkel and Carriles 1985). If such interspecies competition is a serious block to population augmentation, subadult immigration, management, or the occupation of former range, then the design of management measures becomes necessary. These are important considerations relative to the recovery of grizzlies south of Canada, so the topic should rank at least seventh in research priority.

Further Habitat Classification Studies

As land uses intensify, there is a need for further habitat classification and habitat monitoring. The refinements must take two directions: one on a more detailed scale to cope with the design or location of something as small as a bridge or trailhead, the other a broader direction where regional development trends can be addressed or better designed. Land uses, when increased locally in a high-density grizzly bear habitat, call for refinements of the Grizzly Bear Habitat Component (GBHC) technique to the vegetation type or community type level so that more exact bear use and habitat changes can be measured and monitored. Conversely, when management measures are applied to a minimal, broader level (such as an entire valley in a wilderness area), ways of grouping community types or even GBHC's into super components must be devised, or perhaps landsat techniques should be developed and applied.

Community type classification has only begun at the research level, and not all of the research needed for describing GBHC's has been completed. The completion of this research (for example, further classifying GBHC's) should have preceded management application. Any further delays in the research will only result in additional incorrect mapping, and the further waste of mapping funds. This study should rank high, but we relegate it to eighth in priority because other pressing research needs must first catch up.

Land Use Planning, Critical Site, and Conservation Strategy Studies

Land use planning for occupied grizzly habitat is enormously essential, if counterproductive

developments, management programs, implementation procedures, and other undesirable factors are to be controlled. The lack of regional land use planning hurts all sectors of our local economies, our societies, and our resource bases. Sustained development, the key terminology inherent in the World Conservation Strategy (WCS 1980), is equally applicable to grizzly habitat management. It is an approach that has become an absolute necessity in Third World nations where the numbers of people engulf the natural resources. In terms of the grizzly, it includes land use planning, resource development, and the protection of grizzly bear critical sites (high-density areas) simultaneously. It is an economically viable approach; it requires habitat preservation based on the careful planning of sustained resource use.

The methodology of identifying and designing sustained resource use compatible with the maintenance of grizzly bear habitat requires new concepts in ecologically oriented research, combined with economic studies, studies of local political motivations, and the development of communication programs. Critical sites are highly important to bears, but they are also subject to development threats such as subdivisions, timber harvest, and oil and gas development. Ways to sustain local economies while simultaneously maintaining grizzly habitat quality is the challenge of the future and the main goal of this research category. It should have a high priority locally but herein is ranked ninth.

Habitat Corridor Studies

Grizzly bear habitat or travel corridors have been poorly addressed in both research and management and are not considered adequately in the Grizzly Bear Recovery Plan (GBRP 1980). Travel corridors may not contain adequate habitat to sustain local bears, but the roles of corridors in connecting population units and habitats cannot be overly stressed. The loss of travel corridors leads to the isolation of populations into "islands," which greatly amplifies the research and management efforts needed and their costs. This study should rank high where critical corridors are being lost (Evaro Pass, the Coram to West Glacier Area, Marias Pass to East Glacier); however, we rank habitat corridor studies tenth.

Other Research

A wide spectrum of grizzly bear habitat research was initiated in the BGA in 1975, but much of this effort has been curtailed bureaucratically since 1980, so the research is still wanting today when it is so crucially needed. Additional and continuing studies worth mentioning are further cambium use studies; studies of the relationships between drought years, plant food production, bear nutritional levels, and bear-people conflicts; and habitat modeling development.

As habitat conditions change with human population growth, most habitat research outlined herein must be repeated periodically to revalidate the data bases. Grizzly bears are an expensive species to maintain; they will become incredibly expensive to maintain as land uses proliferate. The demands for land use will parallel human population growth, which currently is many millions per month on a world scale. The grizzly will not escape that threat. Long-term research independent of government pressures is crucially essential and must be reinstated to set and guide management direction and planning.

REFERENCES

Craighead, F. C. Grizzly bear ranges and movements as determined by radio-tracking. In: Bears--their biology and management. Pelton, M.; Folk, E.; Lentfer, J., eds. IUCN New Series 40: 97-110, 1976.

Grizzly Bear Research Project. Grizzly bear recovery plan. U. S. Department of the Interior, Fish and Wildlife Service, Wash. D.C.; 1980. 182 p.

Jonkel, C. J. Border Grizzly Project five year summary report. BGP Spec. Rep. 60. Univ. of Montana, 1982.

Jonkel, C. J.; Carriles, H. Black bear/grizzly (brown) bear habitat and range relationships and considerations. In: Missoula, MT; Third Western Black Bear Workshop; [in press].

Mace, R.; Jonkel, C. J. Regional food habits of the grizzly bear in Montana. In: Graber, D., ed. Bears--their biology and management. IBA Symp. Proc. (in press).

Pearson, A. The northern interior grizzly bear *Ursus arctos* L. CWS Rpt. Ser. No. 34. Queens Printer, Ottawa, 1975.

World Conservation Strategy. The world conservation strategy. IUCN publication packet. IUCN Gland, Switzerland, 1980.

Session IV—Habitat Conditions

Chaired by:

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CLIMATE, CARRYING CAPACITY, AND THE YELLOWSTONE GRIZZLY BEAR

H. D. Picton, D. M. Mattson, B. M. Blanchard, and R. R. Knight

ABSTRACT: For a quarter century the Yellowstone grizzly bear population inspired public controversy. The major hypothesis has been that human-caused mortality is a primary influence upon this population. The effects of natural controlling factors have only been nominally explored. Habitat available to the population is characterized by sporadic and widely fluctuating food production primarily controlled by weather. The natural carrying capacity of the overall habitat fluctuates accordingly. During years of low carrying capacity, bears compensate by using a larger area and more of them are likely to die. The naturally low reproductive rate of the grizzly bear precludes quick population adjustment to fluctuating carrying capacity. Management strategies should therefore be geared to a worst-case situation. Indexes of food availability for each habitat type are computed and related to climatic conditions. The range of climatic conditions that can be expected is estimated from recent weather records. The worst-case climatic and food-producing situation is then described and can be prepared for.

INTRODUCTION

The Yellowstone grizzly bear population has inspired public controversy for over 25 years. Although over 30 years of research has produced more data on this grizzly population than any other, its precise status is still uncertain. All estimates of population trend have indicated a decline from 1970 to 1980, if not longer (Craighead and others 1974; Knight and others 1984; Knight and Eberhardt 1985).

The grizzly bear's reproductive rate is naturally low compared to many other mammal species. It's reproductive rate for the late 1970's and early 1980's (Knight and Eberhardt 1985) was lower than during the 1960's (Craighead and others 1974). A major concern has been that combined human-caused and natural mortalities will continue to exceed the birth rate to a point that could be catastrophic to the population.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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The natural environment or carrying capacity for grizzly bears in and around Yellowstone National Park appears to fluctuate widely from year to year (Knight and others 1984). Natural control factors that directly affect the population or indirectly affect it by promoting human-caused mortality have only been nominally explored (Picton 1978; Picton and Knight in press). Effective management is unlikely unless the interaction between the human and natural regimes is understood and appropriately weighted.

The mean climatic conditions indicate the shifts in the biometeorological normal range that influence the ecological carrying capacity of the habitat. Thus, the carrying capacity can be expected to change slowly with the trends in mean precipitation and temperature. Climate is one of the major components of environmental resistance that is greatest at the ecological carrying capacity. If an animal population is near the carrying capacity, changes in environmental resistance (climate) will force changes in the population level. Recent analyses have shown that curvilinear responses such as those expected to be seen near the ecological carrying capacity are present (Fagan 1984) in the litter size-climate index relation previously reported by Picton and Knight (in press).

Short-term changes in climatic conditions might influence populations at the ecological carrying capacity. These year-to-year changes will be superimposed upon the long-term level of the population as determined by the long-term biometeorological normal climate (that is, mean $\pm$ 1 SD). Thus climatic effects have two components: those due to the long-term biometeorological normal climate and those due to the short-term variations about the mean. The weather of the last 10 years has been extreme (Science 1985), with extreme precipitation values (both wet and dry) occurring in 5 of the 9 years in the 1974-82 period in the Yellowstone area (National Oceanographic and Atmospheric Administration 1974-1984).

The objectives of this paper are to use the existing data base on the grizzly bear and climatic records for the Yellowstone area to define the interactions between them, predict the extremes that can reasonably be expected, and suggest management objectives that will take natural factors into consideration.

Data on the grizzly bear population were taken from information gathered by the Interagency Grizzly Bear Study Team (IGBST) from 1973 through

1984 (Knight and IGBST 1975-1984). Climatic data were taken from Yellowstone National Park and U.S. Weather Bureau records. Field methods have been presented in IGBST annual reports (Knight and IGBST 1975-1984) and by Knight and others (1984).

METHODS

Climate Score Calculation

Climate score is an index calculated to approximate the impact of climate on food availability and thus on grizzly bears. The score was calculated on a seasonal and yearly basis, with the algorithm tailored to each season.

Precipitation, temperature, and their deviations from long-term seasonal averages of the Mammoth, Lake, and West Yellowstone weather stations were the variables entered in climate score calculations (table 1). Precipitation variables took the form of percent deviations from long-term averages; that is, seasonal precipitation values were scaled to long-term averages and multiplied by 100. Temperature variables also took the form of absolute percent deviations from long-term averages, but with the freezing point, or 32 ^{o}F (0 ^{o}C), as a base reference point. The 32 ^{o}F was subtracted from the calculation period seasonal temperatures and the long-term means. The resulting values were scaled to long-term averages and multiplied by 100.

Table 1.--Calculation of the seasonal climate score

Season	Percent long-term average precipitation	Percent long-term average degrees F above 32
Winter	WP_i	WT_i
Spring	SP_i	ST_i
Summer	SuP_i	SuT_i
Fall	FP_i	FT_i

SCS_i = spring climate score (year i).

$SuCS_i$ = summer climate score (year i).

FCS_i = fall climate score (year i).

$SuPS_i = (WP_i + SP_i + SuP_i)/3.$

$SCS_i = [(WP_i + SP_i)/2] + [(ST_i + WT_i)]/2.$

$SuCS_i = SuPS_i * [(ST_i + SuT_i)/2].$

$FCS_i = [SuPS_i/2) + (200 - FP_i)/4] + FT_i.$

Spring and winter climates were assumed to influence spring food sources by both spring (SP) and winter precipitation (WP) and temperature. Greater spring and winter precipitation, almost wholly as snow, and colder winter temperatures (WT) were considered to favorably affect spring food availability by causing greater death and debilitation among wintering ungulates. Warmer spring temperatures (ST) were also assumed to increase spring food resources by allowing earlier vegetation growth. Thus calculation of the spring climate score (SCS) took the form:

$$SCS_i = [(WP_i + SP_i)/2] + [(ST_i + WT_i)/2]$$

Summer food resources were assumed to be influenced by spring and summer temperatures and by winter, spring, and summer precipitation. Influences of climate were thought to be reflected primarily in availability and succulence of the grazing resource. Greater averaged winter, spring, and summer (SuP) precipitation and higher spring and summer (SuT) temperatures were assumed to correspond to greater grazing resources. Thus, summer climate score (SuCS) calculation took the form:

$$SuCS_i = [(WP_i+SP_i+SuP_i)/3] * [(ST_i+SuT_i)/2]$$

Availability of fall food sources was assumed to be influenced by growing season moisture conditions as well as fall precipitation and temperatures. Higher fall temperatures (FT) and lower fall precipitation (FP) were assumed to allow access to food sources later into the fall. More favorable growing season moisture conditions, reflected in greater averaged winter, spring, and summer precipitation, were assumed to produce persistent higher quality grazing resources into the fall. Thus, the fall climate score calculation (FCS) took the form:

$$FCS_i = [(WP_i+SP_i+SuP_i)/6]+[(200-FP_i)/4]+FT_i$$

Habitat Quality Index

Calculation of the habitat quality index for Yellowstone Park was based in part on the proportionate cover of habitat types and habitat type mosaics in Yellowstone Park (Despain 1977). Derived coefficients were specific to each season of each year and to each type or mosaic cover. The habitat type coefficients were based on community site and scat analysis data collected during the season and year for which habitat quality was being calculated.

Methodology for coefficient derivation followed Mattson and others (1985). Multiplication of coefficients and proportionate area for each type or mosaic followed by summation of these products over all types yielded an index of habitat quality for the Park for a specific season and year.

RESULTS

Climate

We compared climatic years 1977 and 1980. Greater precipitation in all seasons was the major climatic factor by which 1980 differed from 1977 (table 2). All seasons except winter were wetter than normal during 1980; the composite precipitation total for 6 weather stations was 100 percent of normal. On the other hand, all seasons of 1977 were droughty; the composite total (stations) was 96 percent of normal. Each year had been preceded by a drier year. Temperatures differed less markedly between the years. Spring and winter of 1977 were somewhat colder and fall was slightly warmer than corresponding seasons of 1980.

Greater precipitation during 1980 influenced food availability primarily by producing more during the summer. It also affected the ungulate food source (Houston 1982) by producing more carrion and weakened ungulates during the spring.

Table 2.--Comparisons of climate, habitat, and grizzly bear observations for 1977 and 1980

	1977			
	Spring	Summer	Fall	Annual
Habitat quality index	0.865	0.677	0.714	0.719
Climate score	0.718	0.605	0.967	0.763
Percent of all bears aerially observed outside of Yellowstone National Park on standard flight routes[1]	7	38	0	21
Seasonal rate of movement index	0.827	1.000	1.000	1.000
Mean home range size (km^2)				754
Human-caused known and probable mortality (number of bears)				13
Mean annual rate of weight gain (spring to fall) in kg/day				0.36

[1]These do not represent a systematic aerial survey of all areas outside of Yellowstone Park, but only bears incidentally seen on the consistent radio survey routes.

Slightly warmer 1980 spring temperatures probably also increased the availability of spring grazing opportunities in favored microsites. Conversely, greater fall precipitation coming as snow, during 1980, decreased foraging opportunities and perhaps encouraged earlier denning.

The climate score (table 2) reflects expected climatic influences on food availability during 1977 and 1980. Spring and summer climate scores were substantially higher during 1980 compared to 1977 but differed only marginally during fall of the 2 years.

Food Habits

Food habits during 1977 and 1980 reflected the climatic conditions as well as the less closely predicted availability of whitebark pine (Pinus albicaulis) nuts (fig. 1 and 2).

Although the proportionate volumes of ungulates ingested during the springs of 1977 and 1980 were nearly equal (Knight and IGBST 1977, 1980), total use of winter-killed and weakened animals (based on the proportion of all observed bears using carcasses during comparable survey flights) was less in 1977 than 1980. On a per-unit scat diet-volume basis, ingestion of ungulates was much the same during spring of 1977 and 1980, but was probably significantly less per unit time during 1977.

Proportionate diet item consumption differed markedly between the summers of 1977 and 1980 (fig. 1 and 2). Food is usually readily available during summer so that per-unit-time ingestion rates probably did not differ significantly between the 2 years. Consequently, proportionate diet item volumes give a clear picture of the substantial dietary differences between 1977 and 1980.

The summer diet of 1977 was distinguished by an unusually large proportion of ants and biscuitroot (Lomatium cous) and complementarily sparse amounts of grazed vegetal foods (fig. 1 and 2). These characteristics matched the effects of drought on the availability of summer foods. The foliferous vegetal foods availability and use were apparently very sensitive to the concurrent soil moisture status, whereas ants and root foods were buffered from the short-term drought effects.

The summer diet in 1980 contrasted to that of 1977. The 1980 grizzly bear diet was dominated by the foliferous vegetal foods and included few ants and roots. This agrees with ample soil moisture conditions and average to above-average growing season temperatures.

Fall diet also differed markedly between 1977 and 1980. The fall of 1980 was distinguished by the ingestion of large proportions of whitebark pine nuts, whereas the fall of 1977 was notable for the use of large volumes of yampa (Perideridia gairdneri) roots and virtually no pine nuts.

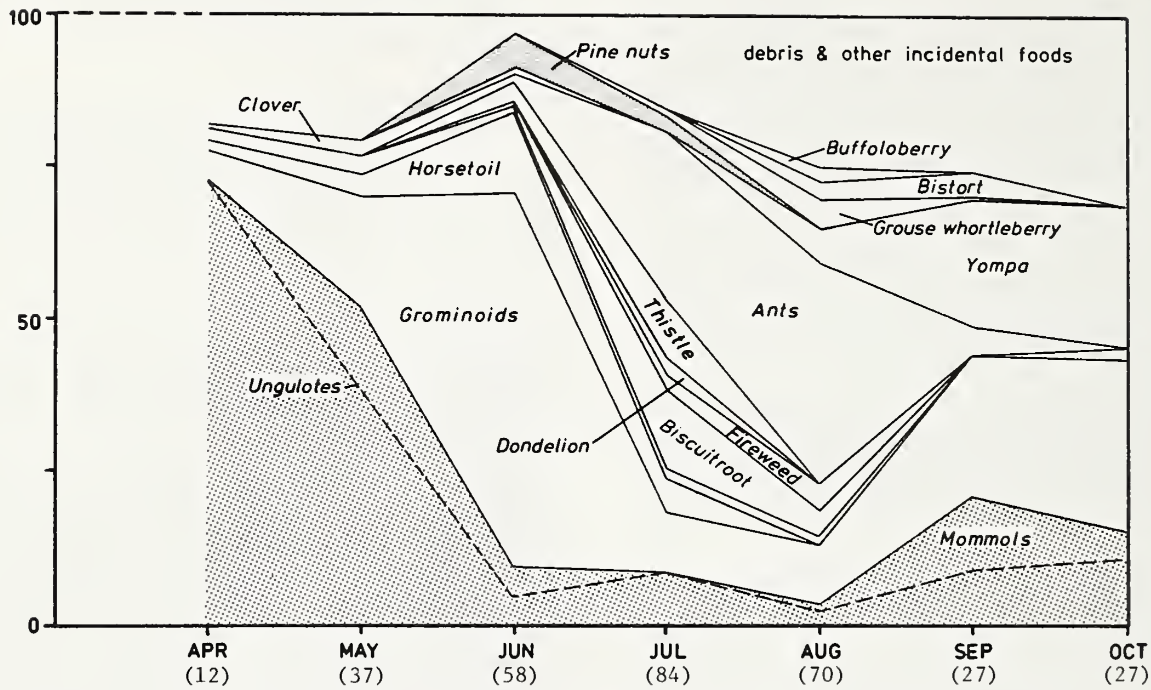

Figure 1.--Volumetric analysis of grizzly bear scats, by month, for 1977. Sample sizes are given in parentheses by month.

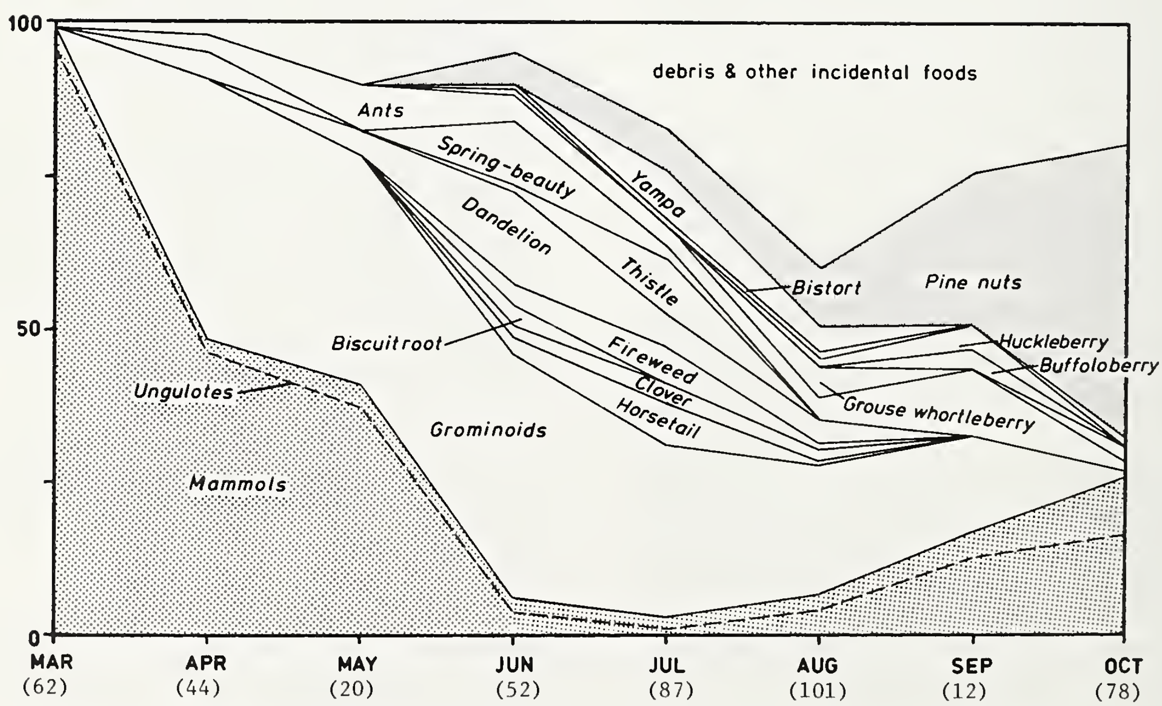

Figure 2.--Volumetric analysis of grizzly bear scats, by month, for 1980. Sample sizes are given in parentheses by month.

Elevational distribution of fall grizzly bear radio relocations reflected the disparity in fall food habits between 1977 and 1980. Average relocation elevation was considerably lower during 1977 (average = 2 361 m) compared to 1980 (average = 2 579 m) (Knight and IGBST 1977, 1980). This apparently reflected the consumption of yampa in mesic habitats at moderate elevations and the consumption of whitebark pine nuts in higher elevation forested habitats.

The dietary patterns reported above are further confirmed by an extensive series of correlations with R^2 values of 0.76 (ants), and 0.80 (graminoids) derived from the 1977 to 1982 climate score and scat analysis data series.

Habitat Quality

The seasonal and annual habitat indexes for Yellowstone National Park, which are estimators of the carrying capacity, reflected food availability, and indirectly, climate for the study years (table 2). The habitat quality index rates 1980 as a much higher quality year than 1977. Of the 7-year (1977-83) study period, only 1981 rated as a poorer year than 1977, whereas no other year exceeded 1980 in quality (table 3).

The seasonal deviation in the habitat index was greatest between the summers of 1977 and 1980. The 1977 summer food habits were notable, during the 1977-83 study period, for the paucity of grazed vegetal foods and the large volume of ants. Conversely, the 1980 summer habitat values were slightly enhanced over those normally associated with ample grazing resources by a large proportion of high-energy-value fruit (huckleberry [*Vaccinium globulare*] and grouse whortleberry [*V. scoparium*]). Differences between the habitat indexes for the two summers were consequently large (0.677 compared to 1). Summer climate scores closely matched the summer habitat indexes,

Table 3.--A summary of the annual climate scores and habitat quality indexes for the 1977 to 1982 period

	Year					
Index	1977	1978	1979	1980	1981	1982
Climate score	0.740	0.903	0.887	0.969	0.838	1.000
Habitat quality index	0.752	0.802	0.943	1.000	0.596	0.846
Mean home range size (km^2)	754	642	766	338	413	366

suggesting that annual differences in habitat quality probably reflected winter, spring, and summer climates.

Seasonal differences in habitat quality for 1977 and 1980 were least during spring. Although the 1977 index value was less, in large part because of less unit-area consumption of ungulates (Mattson and others this volume), the disparity was not great. Feeding site and climate data suggest that the fewer available ungulates during the spring of 1977 were in part compensated for by a greater area of available grazing resource. The differences between the spring climate score and the spring habitat index probably reflected the greater sensitivity of the climate score to the availability and use of the spring grazing resource.

Differences in the fall habitat index for the two study years primarily reflected the availability and use of high-value pine nuts during 1980 and their virtual absence from the landscape and diet in 1977. The habitat index score during 1977 was buoyed, however, by the near-normal consumption of the equally high-value ungulates.

The large discrepancy between fall values of the climate and habitat indexes also primarily reflected use of pine nuts during 1980. Availability of pine nuts is largely dissociated from the contemporaneous climate, since pine nuts need 2 years to mature. Thus the habitat index values derived from the use of pine nuts are largely unpredicted by the fall climate score as presently calculated.

Movements

Three variables associated with grizzly bear movements were measured on a seasonal or annual basis: (1) the percentage of all bears located outside of Yellowstone Park that were observed from the air during consistent radio survey flights (these were not attempts to survey all areas outside the park); (2) an index of the seasonal rate of movement; and (3) the average annual home range size for grizzlies radio-tracked during the entire study year. These variables indicated that grizzly movements during 1977 and 1980 were very sensitive to climatic and habitat conditions (tables 2 and 3).

The percentage of bears located outside Yellowstone Park that were observed from the air showed annual and seasonal differences between 1977 and 1980. The best year for habitat quality during the 1977 to 1983 study period was 1980. Significantly, during that year, no grizzlies were observed from the air outside of Yellowstone Park. In contrast, 38 percent of all grizzlies observed during the summer of 1977 were seen outside the park. Averaged over the year, 21 percent of all grizzlies seen in 1977 were located outside the park. This movement relationship is further supported by the 6-year (1977-82) correlation, which has an R^2 value of 0.53 ($P < 0.1$).

Seasonal and annual rates of movement were also decidedly sensitive to climate and habitat conditions. During summer and fall, movements were approximately one-half as much during 1980 as they were during 1977. Wetter climatic conditions and greater habitat value apparently produced less mobility. Spring movements showed an opposite response to climate and habitat. Greater mobility was associated with greater habitat quality (that is, greater numbers of available ungulates).

Smaller annual home range sizes during 1980 compared to 1977 reflected the habitat quality and climate. The smaller ranges were apparently a result of wetter climatic conditions and greater habitat quality and climate. The smaller ranges were apparently a result of wetter climatic conditions and greater habitat quality. The 1977-82 data base gave a correlation R^2 value of 0.66 ($P < 0.05$) to support the belief that this is a consistent relationship.

Mortality

Human-caused mortalities in recent years have occurred primarily when grizzlies attempted to acquire human foods within the human domain. The numbers of such mortalities were quite sensitive to climatic and habitat conditions (table 2). During the austere year of 1977 over twice as many grizzlies died of human-related causes as during 1980. Apparently grizzly mortality was much more likely during drier years such as 1977, when fewer ungulates and few pine nuts were available, than during a year when all high-value foods were seasonally abundant, as in 1980. A correlation analysis for the 1977-82 period (for summer R^2=0.98 [$P < 0.01$]; for fall R^2=0.91 [$P < 0.01$]) suggests that this was a general relationship.

Weight Gain

Seasonal weight gain was the final response variable examined in this analysis. Again, the pattern was consistent. The average daily weight gain under austere 1977 conditions was less than one-half the 1980 rate (table 2; Knight and IBGST 1977, 1980).

Other

Other population parameters appear to respond to annual variations in climate and habitat quality. Cub-sow ratios and age-class survivorship are examples of such parameters.

For example, from 1977 to 1982, the cub-sow ratio was correlated with habitat quality averaged for the contemporaneous spring and summer with an R^2 of 0.82 ($P < 0.05$).

It was further found that the survivorship of cohorts through their first 5 independent years was inversely correlated with the habitat quality they had experienced as cubs (R^2=0.83, $P < 0.05$).

DISCUSSION

We examined the impact of climate upon various biological attributes during 2 years with contrasting climates. The results seen during these 2 years were also compared to a 7-year data set (1977-83) when possible.

The climate score used in this paper follows the degree day approach common in agronomy. The habitat quality index is an attempt to represent the bears' view of the habitat. The analytical procedures emphasized the annual variations from mean conditions.

A response syndrome was clearly present. Low availability of pine nuts and years with poor growing conditions increased the amount of ants and roots in the summer and fall diet as compared to grazed vegetal foods and pine nuts. This in turn resulted in a lower weight gain, an increase in foraging movements, and a greater human-induced mortality rate.

The data are consistent with the net energy gain movement-triggering hypothesis of Baker (1978). That is, movement is stimulated, resulting in larger home ranges, when the net energy gain drops below a threshold level. The weight gain relationships with diet appear to be consistent with mammalian nutrition studied that suggest that late summer-fall hyperphagia might be triggered by an increase in lipids and certain simple sugars in the diet, which in turn stimulate fat deposition (Glick 1984). This interpretation is consistent with the food analyses done by Mealey (1975) and indicates that diet quality as well as quantity is important. The shift away from the grazing resource during dry years probably is due to the early loss of succulents and related nutrients during these dry years. The shift is more likely due to loss of quality rather than quantity and thus competition with ungulates is probably not significant.

Harting (1985) found that use of ungulates and human garbage can make otherwise unattractive habitats usable to grizzlies. The bears in his study that followed this feeding strategy tended to forage more widely than animals relying upon the vegetal resource. Increased employment of a comparable feeding strategy probably characterizes the response of Yellowstone grizzlies to droughty years. The high mortality rate of the bears during dry years suggests that the bears have or develop a preference for human-associated foods, are forced into areas with greater human presence and potential conflict, because the habitat within one home range diameter of the park is saturated, or simply randomly increase movements beyond the park boundaries.

The annual rate of increase of the Yellowstone grizzly population (Knight and Eberhardt 1985) is below the level expected for a mammal of its size from the general mammalian reproductive allometric equation. Thus, the population is at carrying capacity and is undergoing K selection. This is further confirmed by the litter size-climate

relationships previously reported (Picton 1978; Picton and Knight in press). This paper examines some of the mechanisms by which a population responds to climatic variation. Because of the small number of females (Knight and Eberhardt 1984), it is questionable whether the present population can obtain full benefit of positive climatic variations. It may therefore be desirable to formulate and discuss management options to help the population benefit more from the climatic variations than is possible with its current structure and long turnover time.

The Yellowstone grizzly bear reserve should be maintained with an eye to the future. Yellowstone National Park lies in the convergence zone between the subtropical and the circumpolar jet streams (Stockton 1973); thus the climate can vary substantially from year to year, depending upon the relative shifts of the two jet streams. This study includes years having bad climatic conditions as well as some good ones; however, long periods at the extremes are not included. If the Yellowstone grizzly reserve is to be managed for the indefinite future we must consider the probable atmospheric CO_2-induced climate change that may be upon us within the next 10 years (Kellogg and Schware 1981). Grizzly bear-climate studies suggest that this population may be significantly affected by such a change, which may involve an annual mean temperature rise at the latitude of Yellowstone area equal to or exceeding the most extreme years of the 20th century and approaching the estimate for the Altithermal period (about 5,500 years before present) (Manabe and Wetherald 1980; Houston 1982). Research and management policies should focus not only on the individual poor year contingency, but also on foreseeable climate change options so that the Yellowstone grizzly reserve remains a reserve for the indefinite future.

REFERENCES

Baker, Robin R. The evolutionary ecology of animal migration. New York: Holmes and Meier Publishers, Inc.; 1978. 1012 p.

Calder, William A. Size, function and life history: scaling in animals. Cambridge, MA: Harvard University Press; 1984. 431 p.

Craighead, John J.; Varney, J. R.; Craighead, Frank C., Jr. A population analysis of the Yellowstone grizzly bears. Bulletin 40. Missoula, MT: University of Montana, Montana Forest Conservation Experiment Station; 1974. 20 p.

Despain, D. 1977. Personal communication. Yellowstone National Park, WY: National Park Service.

Fagan, R. 1974. Personal communication. Juneau, AK: University of Alaska.

Glick, Z. Meal intake and brown adipose tissue in the rat. Nutrition and Behavior. 2:65-75; 1984.

Harting, Albert L. Activity patterns and foraging strategies of Yellowstone grizzly bears. Bozeman, MT: Montana State University; 1985. 103 p. M.S. thesis.

Houston, Douglas B. The northern Yellowstone elk: ecology and management. New York: Macmillan; 1982. 474 p.

Kellogg, William W.; Schware, Robert. Climate change and society: consequences of increasing atmospheric carbon dioxide. Boulder, CO: Westview Press; 1981. 178 p.

Knight, Richard R.; Eberhardt, Lee L. Projected future abundance of the Yellowstone grizzly bear. Journal of Wildlife Management. 48: 1434-1438; 1984.

Knight, Richard R.; Eberhardt, Lee L. Population dynamics of Yellowstone grizzly bears. Ecology. 66: 323-334; 1985.

Knight, Richard R.; Interagency Grizzly Bear Study Team (IGBST). Annual reports of the Interagency Grizzly Bear Study Team. Bozeman, MT: U.S. Department of the Interior, Interagency Grizzly Bear Study Team; 1973-1984.

Knight, Richard R.; Mattson, David J.; Blanchard, Bonnie M. Movements and habitat use of the Yellowstone grizzly bear. Bozeman, MT: U.S. Department of the Interior, Interagency Grizzly Bear Study Team; 1984. 60 p.

Manabe, Syukuro; Wetherald, Richard T. On the distribution of climate change resulting from an increase in CO_2 content of the atmosphere. Journal of Atmospheric Science. 39: 99-118; 1980.

Mealey, Steven P. The natural food habits of free ranging grizzly bears in Yellowstone National Park, 1973-1974. Bozeman, MT: Montana State University; 1975. 158 p. M.S. thesis.

National Oceanographic and Atmospheric Administration. Climatological data: Montana; Climatological data: Wyoming. Asheville, NC: National Oceanographic and Atmospheric Administration; 1972-1983.

Picton, Harold D. Climate and the reproduction of grizzly bears in Yellowstone National Park. Nature (London). 274: 888-889; 1978.

Picton, Harold D.; Knight, R. R. Using climate data to predict grizzly bear litter size. In: Proceedings February 1983 sixth international bear conference; Grand Canyon, AZ; [In press].

Science. Wild string of winters confirmed. Science. 227(4686): 506; 1985.

Stockton, Charles W. A dendroclimatic analysis of the Yellowstone National Park Region, Wyoming-Montana. Tucson, AZ: University of Arizona, Laboratory of Tree Ring Research; 1973. 56 p.

ANALYSIS OF GRIZZLY BEAR HABITAT IN THE BOB MARSHALL WILDERNESS, MONTANA

Richard D. Mace

ABSTRACT: The Grizzly Bear Recovery Plan of 1982 was adopted to provide a sequence of management actions necessary for the conservation and recovery of grizzly bears in selected portions of the contiguous 48 States. The Plan identified six ecosystems, the largest of which is the Northern Continental Divide Ecosystem. Although the Bob Marshall Wilderness constitutes approximately 17 percent of this ecosystem, no habitat descriptions for the Wilderness were available. Recent ecological studies have shown that grizzly bear habitat use patterns can be explained in terms of the distribution of major food items. Therefore, the primary objective of this study was to establish detailed vegetation descriptions of habitat components occurring in the temperate, subalpine, and alpine zones of the study area. Eight habitat components were identified and sampled. Within these components, 28 vegetation types were sampled by stratified random sampling. Vegetation information was also obtained for three forest habitat types. The foraging quality of these 28 vegetation types was evaluated for two foraging seasons (herbaceous season, fruit season). Each vegetation type was evaluated on the basis of succulent foods, modified stems (roots, corms, bulbs), and fruit. During the herbaceous season, the tallgrass/*Senecio triangularis* vegetation type (subalpine meadow component) ranked first in succulent foods. Several vegetation types of the avalanche chute complex and flood plain complex also ranked high in succulent foods for this season. Vegetation types of the flood plain complex, slabrock, and alpine complex components ranked high for modified stems. The *Abies lasiocarpa*/*Xerophyllum tenax*-*Vaccinium globulare* forest habitat type ranked highest of all types for those fruits favored by grizzly bears. Abbreviated descriptions of each component and vegetation type are given. This information will assist wilderness management programs and will aid in the comparisons of habitat quality among areas.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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INTRODUCTION

The land base occupied by the grizzly bear in the contiguous 48 States has been divided into six major ecosystems, the largest of which, the Northern Continental Divide, is located in western Montana. Although the Bob Marshall Wilderness constitutes approximately 17 percent (424 500 ha) of this ecosystem, no habitat descriptions for the Wilderness were available. As stated in the Grizzly Bear Recovery Plan (U.S. Department of the Interior 1982): "The value of wilderness areas to grizzly bears in this ecosystem is undocumented. They may contain habitat values superior, inferior, or equal to those in peripheral areas."

The objectives of this study were to establish detailed vegetation descriptions of habitat components occurring in the temperate, subalpine, and alpine zones and to develop a seasonal ranking of grizzly bear habitat based on food composition and temporal availability.

STUDY AREA DESCRIPTION

The study area was located in the southern portion of the Bob Marshall Wilderness. Major drainages within the approximately 40 400-ha study area included Gordon, Babcock, and Youngs Creeks and a portion of the South Fork of the Flathead River flood plain (fig. 1).

The area is rugged mountain terrain located within the Rocky Mountain Cordillera. Parent material is of sedimentary origin. The western study area boundary, the Swan Range, was uplifted and tilted between 70 and 60 million years ago (Deiss 1958). Mountain glaciers have formed the U-shaped valleys, cirques, hanging valleys, horns, and aretes in evidence today. Elevation varies from 1 423 m along the South Fork of the Flathead River, to 2 761 m on Ptarmigan Peak along the Swan Crest.

Maritime air masses moving from the Pacific Ocean strongly influence the study area (Daubenmire 1969); however, precipitation in the southern portion of the Bob Marshall is moderated by the Mission Mountains to the west.

Rugged mountain topography and complex local climates create an array of vegetation. Dry open slopes occur in rain shadows, and cool, moist

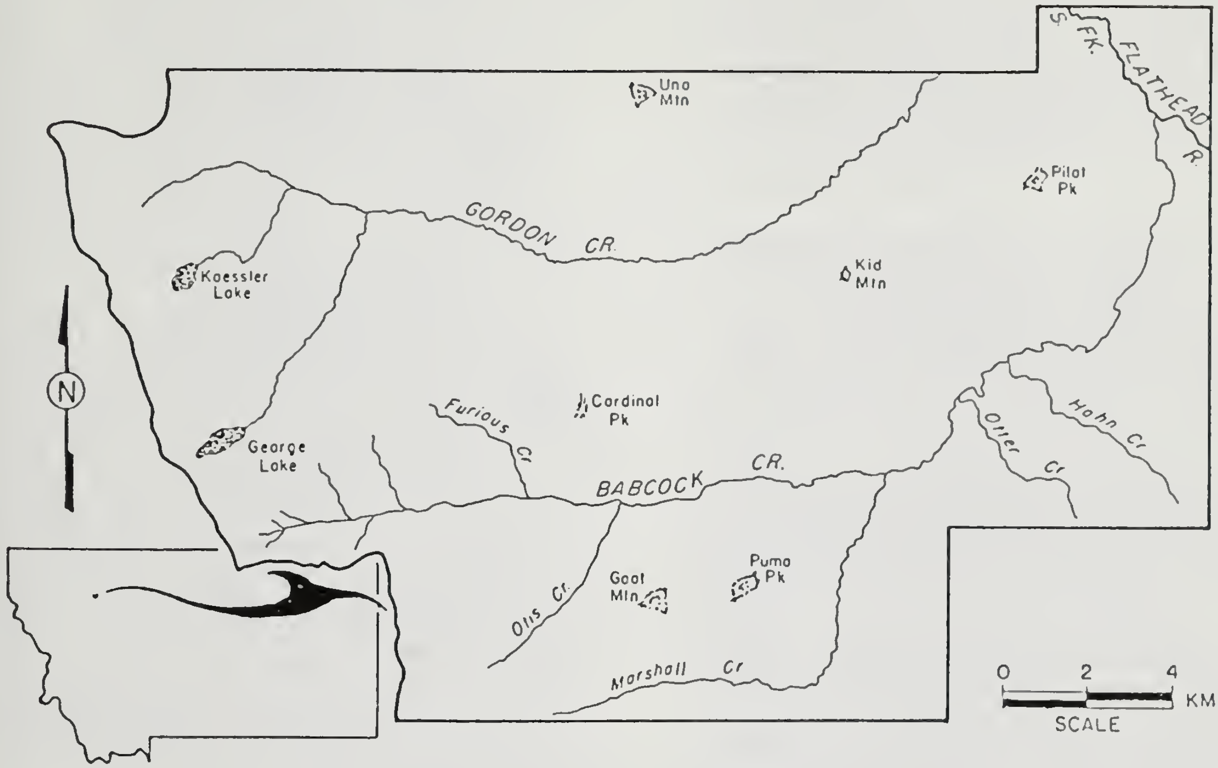

Figure 1.--The study area.

drainages are located in areas of relatively high precipitation and cloud cover (Arno 1979). The study area contains the Douglas-fir (Pseudotsuga menziesii), spruce (Picea spp.), and subalpine fir (Abies lasiocarpa) habitat type (h.t.) series of Pfister and others (1977). Plant taxa have adapted to natural fire, and seral vegetation forms complex mosaics throughout the area. The history and influence of fire in the Northern Rocky Mountains are given by Steele (1960), Habeck and Mutch (1973), and Arno (1980).

METHODS

Field Procedures

Field work was conducted from June through September of 1982 and 1983. Existing habitat component categories served as a foundation for vegetation sampling. Component definitions developed for the lower South Fork of the Flathead River (Zager and others 1980), the Mission Mountains (Servheen 1981), and the Rocky Mountain East Front (Aune and Stivers 1982) were field-checked to determine feasibility of use.

A 3-week initial reconnaissance was conducted to determine the general spatial arrangement of major vegetation types within each designated habitat component. Sample plots were placed within these vegetation types by stratified random sampling. Open-timbered and timbered vegetation (30 percent to 60 percent and >60 percent canopy cover) were sampled using 375-m^2 circular plots. Small vegetation types without conifer overstories were sampled using circular plots of 5 m^2. The number of plots taken in each vegetation type was determined in the field by construction of a species-area curve (Mueller-Dombois and Ellenberg 1974). Sampling of a specific vegetation type was terminated when no new taxa were encountered after three consecutive plots were taken. Complete taxa lists were compiled, although grasses and sedges were combined. Cover values for each plant species and nonvascular material were visually estimated using the modified Daubenmire cover classes of Pfister and others (1977): 0=absent; T=trace-1 percent; A=1-5 percent; B=5-25 percent;

C=25-50 percent; D=50-75 percent; E=75-95 percent; and F=95-100 percent.

Botanical nomenclature followed Hitchcock and Cronquist (1973). Timbered sites were keyed to the appropriate forest habitat type of Pfister and others (1977). Tree, shrub, and herbaceous cover per stratum were recorded in each plot. Height categories employed were: A=0-0.9 m; B=0.9-2.0 m; C=2.0-9.0 m; and D= >9.0 m.

Analytical Procedures

Pressed plant specimens were verified by Peter Stickney (Intermountain Research Station, Missoula, MT). Vegetation data were then assembled into association tables to scrutinize relationships among plots (Mueller-Dombois and Ellenberg 1974). Plot data were then entered into a DEC-20 computer.

Average percent cover was derived by summing the cover class midpoints for a species and then dividing the summation by the total number of plots in the vegetation type. Relative cover and percent occurrence values were also determined for each taxa.

A list of food items in the study area was collated using recent literature on grizzly bear food habits from the Northern Rocky Mountains of the United States and southern British Columbia, Canada (Russell and others 1979; Aune and Stivers 1982; Craighead and others 1982; Sumner and Craighead 1973; Mace and Jonkel in press). Food items were placed into one of three major food categories: succulent vegetation; modified stems (roots, bulbs, or corms); or fruit. Each food item was given a seasonal preference rank. A rank of 3 represented an often-selected food; a rank of 2 was given to food plants of moderate use; and a rank of 1 meant low use. For each sample plot within a vegetation type, preference ranks were multiplied by the midpoint of the cover class of each food to develop a "food item importance value" (FIIV). "Vegetation type importance values" were obtained by simply summing the FIIV's in each plot and then averaging over all plots in the vegetation type.

Two seasonal categories were used: a "herbaceous foraging season" (den emergence to July 31), and a "fruit foraging season" (August 1 to den entry). Test of statistical differences among "vegetation type importance values" for each season and each food category were accomplished using nonparametric Mann-Whitney (M-W) procedures (Nie and others 1975).

RESULTS

Eight grizzly bear habitat components were designated for the study area. Within these components, 28 vegetation types were identified and sampled as follows:

1. Flood Plain Complex Habitat Component
    a. _Salix_ spp. flat VT
    b. Sandbar and gravel bar VT'S
    c. _Carex_ spp. VT
    d. Mesic herbaceous meadow VT
    e. Riparian _Picea_ VT
    f. _Populus trichocarpa_ VT
    g. Terrestrial _Picea_ VT
    h. Xeric graminoid meadow VT
2. Avalanche Chute Complex Habitat Component
    a. Streamside VT
    b. _Alnus_ shrubfield VT
    c. _Xerophyllum tenax_ VT
    d. Xeric, warm-aspect VT
    e. Mesic herbaceous fan VT
    f. Xeric herbaceous fan VT
3. Timber Creek Bottom Habitat Component
    a. Closed timber VT
    b. Glade (opening) VT
4. Mountain Sidehill Park Habitat Component
    a. Mixed graminoid VT
    b. Xeric bunchgrass VT
5. Burn Shrubfield Habitat Component
    a. Temperate zone burn shrubfield VT
    b. Subalpine zone burn shrubfield VT
6. Subalpine Meadow Habitat Component
    a. Shortgrass/_Phyllodoce empetriformis_ VT
    b. Hydromesic herbaceous VT
    c. Tallgrass/_Senecio triangularis_ VT
7. Slabrock Habitat Component
8. Alpine Complex Habitat Component
    a. Fellfield VT
    b. Mesic alpine meadow VT
    c. Vegetated rock/talus VT

Given below are brief descriptions of each habitat component and associated vegetation types. Complete vegetative and physiographic descriptions are given by Mace (1984).

Grizzly Bear Habitat Components

Flood plain complex habitat component.--The flood plains of the study area were divided into two zones, riparian and terrestrial (U.S. Department of Agriculture 1978; Pfister and Batchelor 1984). The riparian zone was adjacent to the river channel and susceptible to annual or periodic flooding. The terrestrial zone was that area of undulating and terraced valley floor not subject

to flood waters. Nonforested types of the riparian zone included willow (Salix spp.) flats, mesic herbaceous meadows, sand bars, and gravel bars. Mature stands of the spruce/queencup beadlily (Clintonia uniflora) and spruce/fragrant bedstraw (Galium triflorum) h.t. series were present on unburned islands and oxbows. Blocks of highly stocked lodgepole pine (Pinus contorta) and Douglas-fir interspersed with xeric graminoid/big sagebrush (Artemisia tridentata) meadows occupied well-drained terraces of the terrestrial zone. The flood plain complex was formed by valley glaciers and exhibited a U-shaped topography. The elevation of these low-gradient river or creek bottom lands varied from 1 415 to 1 576 m.

Avalanche chute habitat component.--Avalanche chutes were a combination of vegetation types subjected to annual or periodic cascading snow. They typically formed in the linear and concave irregularities of steep mountain slopes; however, chutes also existed as extensive open and undulating parks beneath steep mountain headwalls and palisades. Vegetation types of this component included supple-stemmed alder (Alnus spp.) shrubfields on cool and moist aspects; mesic streamside vegetation; xeric-aspect vegetation; and beargrass (Xerophyllum tenax) bowls. Seven avalanche chutes were sampled, each of which represented a major cardinal direction.

Timbered creek bottom habitat component.--The secondary drainages of the study area exhibited an overstory canopy cover greater than 60 percent. Habitat types in the sample areas were either subalpine fir/bluegrass reedgrass (Calamagrostis canadensis) or subalpine fir/fragrant bedstraw. Small openings (the glade VT) in the canopy along stream channels or in "blow-down" areas were common. The elevation of this habitat component varied from 1 439 to 1 740 m.

Burn shrubfield habitat component.--Seven burn shrubfields were sampled. These were divided into temperate zone burn VT (<2 121 m), and a subalpine zone burn VT (>2 121 m). The most recent period of burnings for temperate zone shrubfield was 1926. Paired-plot data suggest that these sites were once an open-timbered Douglas-fir forest. Herbaceous dominants included arrowleaf balsamroot (Balsamorhiza sagittata), western hedysarum (Hedysarum occidentalis), and fireweed (Epilobium angustifolium). Evergreen ceanothus (Ceanothus velutinus) and serviceberry (Amelanchier alnifolia) were dominant shrubs.

The subalpine zone burns sampled burned either in 1929 or 1934 and occurred within the subalpine fir/beargrass-grouse whortleberry (Vaccinium scoparium) h.t. Beargrass was the dominant taxa, having a relative cover value of 52 percent. Arrowleaf balsamroot, entire-leaved aster (Aster integrifolius), and fleabane (Erigeron spp.) dominated particularly xeric and shallow-soiled microsites. Globe huckleberry (Vaccinium globulare) exhibited a 3 percent cover.

Forest habitat types.--Three forest h.t.'s were sampled for cover and occurrence of shrub taxa. The subalpine fir/beargrass-globe huckleberry h.t. occurred on southern exposures in the temperate and lower subalpine zones. This type was sampled on benches above timbered creek bottoms and in open-timbered to timbered stringers in avalanche chutes. The subalpine fir/woodrush (Luzula hitchcockii)-grouse whortleberry h.t. occupied sites above 2 121 m on all exposures. The subalpine fir/fool's huckleberry (Menziesia ferruginea) h.t. occurred on northern exposures.

Mountain sidehill park habitat component.--Openings in the forest canopy at midelevations occurred on mountain slopes. Although present on all aspects, such sidehill parks typically occupied residual soils on southern exposures. These parks were often dominated by grasses and maintained by periodic light ground fires (Johnson 1982). Two vegetation types of this component were identified. The first, a mixed graminoid VT, was dominated by bluebunch wheatgrass (Agropyron spicatum), Kentucky wheatgrass (Poa pratensis), common timothy (Phleum pratense), western needlegrass (Stipa occidentalis), and fringed bromegrass (Bromus ciliatus). Serviceberry and oregongrape (Berberis repens) were considered dominant shrubs. Nonvascular ground cover was 19 percent. Numerous parks supported a dry bunchgrass vegetation dominated by Idaho fescue (Festuca idahoensis). Such areas, termed a xeric bunchgrass VT, generally exhibited a low cover of plant taxa and high cover of bare ground and rock (69 percent cover).

Slabrock habitat component.--The uplifting and tilting of parent material during the mountain-building eras resulted in exposed and often terraced slabs of glacially scoured rock. Subsequent erosion allowed soil and vegetation development between these slabs of rock. This slabrock component was located at the head of cirque basins. Dominant herbs were woodrush pussy-toes (Antennaria luzuloides), beargrass, and subalpine buttercup (Ranunculus eschscholtzii). Sandberg's biscuit-root (Lomatium sandbergii) was restricted to the most xeric habitats, either in slabrock crevices or on gravelly surfaces abutting the rock slabs. The cover values of rock slabs, total ground vegetation, and conifers were 36, 48, and 16 percent, respectively.

Subalpine meadow habitat component.--Open meadows of variable species composition were present beneath the headwalls of cirque basins. Meadows were also present along the terminus of snow fields and near perennial and ephemeral streams. Elevation of the meadows sampled varied from 2 061 to 2 291 m. Three distinct subalpine meadow VT's were sampled. A dense turflike pattern of vegetation was distinctive in the shortgrass/red mountain-heather (Phyllodoce empetriformis) VT. Senecio spp. (S. pseudaureus or S. resedifolius), elkslip marigold (Caltha leptosepala), and fleabane (Erigeron spp.) were dominant herbs. Surface and subsurface water

runoff saturated soils in which vegetation was growing in the hydromesic herbaceous VT. Dominant taxa in these hydric microsites included brook saxifrage (Saxifraga arguta), elkslip marigold, glaucous zigadenus (Zigadenus elegans), and alpine laurel (Kalmia polifolia). The third subalpine meadow type (tallgrass/Senecio triangularis VT) occurred within the subalpine fir/bluejoint reedgrass and the subalpine fir/woodrush h.t.'s. These partially shaded meadows exhibited a luxuriant growth of grasses and sedges. The dominant herb and grass were arrowleaf groundsel (Senecio triangularis) and bluejoint reedgrass.

Alpine complex habitat component.--Sites exhibiting characteristic alpine flora were generally found above an elevation of 2 310 m. Nontimbered alpine vegetation consisted of xeric fellfields and mesic forb/sedge meadows. Exposed bedrock, boulder fields, and sparsely vegetated cobblefields comprised large areas of this component. The fellfield VT was sampled on the most severely exposed and wind-swept surfaces of mountain peaks. Cushion plants were conspicuous in fellfields and included pale alpine forget-me-not (Eritichium nanum), Rocky Mountain douglasia (Douglasia montana), alpine smelowskia (Smelowskia calycina), and few-seeded draba (Draba oligosperma). White dryas (Dryas octopetala) was the subshrub of greatest coverage. The mesic alpine meadow VT was located directly below sites of high snow accumulation. The two dominant herbs in this type were subalpine buttercup and creeping sibbaldia (Sibbaldia procumbens). Unstable rock and talus slopes typified the vegetated rock/talus VT. Arnica (Arnica spp.), leafy-bract aster (Aster foliaceus), and yellow buckwheat (Eriogonum flavum) were dominant herbs.

Seasonal Ranking of Vegetation Types

The 28 vegetation types and three forest habitat types were evaluated for two foraging seasons: a herbaceous season (den emergence to July 31), and a fruit season (August 1 to den entry). Three assumptions were made in the seasonal analyses of habitat:

1. Four major categories of foods would be selected by grizzly bears during those seasons when the foods were phenologically available. The four categories were:

    a. Succulent vegetation (both seasons)
    b. Underground roots, corms, and bulbs (modified stems) dug by grizzly bears during both seasons
    c. Fruit (fruit foraging season)
    d. Whitebark pine nuts (both seasons)

2. A grizzly bear would forage in a small vegetation type if preferred foods (as dictated by food category) were present, even if the corresponding habitat component was of low seasonal value. Grizzly bears would select types with the greatest cover and occurrence of these foods.

3. Grizzly bears would find adequate cover and occurrence of grasses and sedges in all vegetation types. Elimination of these food items from seasonal rankings would provide a more realistic indication of the foraging value of the type.

Seasonal evaluations of vegetation types were based on the percent cover and seasonal preference ranks of specific food items of each food category. Food items used in these analyses (table 1) were collated from pertinent food habits literature.

Habitat components and their associated vegetation types were considered to be available to grizzly bears during all snow-free months. Table 2 shows the relationships among component availability, food categories, and foraging season. All habitat components except the slabrock, subalpine meadow, and alpine complex components were available throughout the grizzly bear's active season.

Vegetation Type Comparison for the Herbaceous Foraging Season (Den Emergence-July 31)

Table 3 shows vegetation type rankings for succulent plants and modified stems. The tallgrass/Senecio triangularis VT of the subalpine meadow component ranked highest of all types for succulent food items, even though not available until July. The importance value of this type was significantly greater than the closest ranking Alnus VT of the avalanche chute component (M-W $p=0.04$). The Alnus VT and the riparian Picea VT (flood plain complex habitat component) ranked second and third respectively. These two types were available in May. The remainder of the top 10 ranking vegetation types were present in either avalanche chutes, creek bottoms, or flood plain complexes.

Table 4 gives the cover and occurrence of several "key" succulent foods per vegetation type. Gramineae/Cyperaceae was present in all types and showed the highest cover values of all foods. Cow parsnip (Heracleum lanatum) occurred in moist and cool vegetation types. The streamside VT and small openings in the Alnus VT had higher cover values of this food than other avalanche chute types. The mesic herbaceous fan VT of north-facing and west-facing chutes also showed high cover values of this food. Willow flats and mesic herbaceous meadows showed higher cover values of cow parsnip than other flood plain complex types.

Horsetail (Equisetum spp.) had the greatest observed cover in the glade VT of timbered creek bottoms. In the flood plain component, this food was most abundant in the riparian Picea VT and the Salix flat VT. Horsetail was noticeably absent in all avalanche chute types, suggesting the importance of a moist, cool, and shaded microenvironment as a growth medium.

The sand bar VT (flood plain complex) ranked highest of all types for roots, corms, and

Table 1.--Grizzly bear food items and preference ranks

Food item	Vegetation	Modified stems	Fruit
FORBS:			
Achillea millefolium	1		
Allium cernuum		2	
Allium schoenprasum		2	
Allium spp.		2	
Angelica arguta	3		
Aster conspicuus	1		
Aster foliaceus	1		
Aster occidentalis	1		
Aster spp.	1		
Astragalus alpinus		2	
Astragalus bourgovii		2	
Astragalus robbinsii		2	
Astragalus spp.		2	
Castilleja spp.	1		
Cirsium spp.	2		
Claytonia lanceolata		3	
Equisetum arvense	3		
Equisetum spp.	3		
Erythronium grandiflorum		3	
Fragaria virginiana	3		
Hedysarum occidentale		1	
Heracleum lanatum	3		
Ligusticum canbyi	2		
Ligusticum spp.	2		
Lomatium dissectum		1	
Lomatium cous		3	
Lomatium macrophyllum		3	
Lomatium sandbergii		3	
Lomatium spp.		3	
Osmorhiza chilensis	3		
Osmorhiza purpurea	3		
Osmorhiza occidentalis	3		
Osmorhiza spp.	3		
Oxytropis campestris		3	
Polygonum bistortoides		2	
Senecio triangularis	2		
Trifolium spp.	3		
Taraxacum spp.	3		
Valeriana sitchensis	2		
Valeriana occidentalis	2		
Veratrum viride	2		
SHRUBS:			
Amelanchier alnifolia			3
Arctostaphylos uva-ursi			2
Cornus stolonifera			2
Prunus virginiana			2
Rhamnus alnifolia			2
Ribes lacustre			1
Ribes viscosissimum			1
Ribes inerme			1
Ribes hudsonianum			1
Ribes spp.			1
Rosa acicularis			1
Rosa woodsii			1
Rosa spp.			1
Rubus idaeus			1
Rubus spp.			1
Shepherdia canadensis			3
Sorbus scopulina			3
Vaccinium scoparium			2
Vaccinium caespitosum			2
Vaccinium globulare			3

bulbs (table 3). Before July, the Xerophyllum tenax VT (avalanche chute complex) and the temperate zone burn VT also ranked relatively high. Beginning in July, the slabrock component and the mesic alpine meadow VT ranked 2 and 3 respectively. There was no significant difference between the sand bar VT and the slabrock component (M-W p=0.30).

A summary of those food items whose underground parts would be dug by grizzly bears is presented in table 5. During the early portion of the herbaceous foraging season, wild onion (Allium spp.) and milk vetch (Astragalus spp.) were the most widely distributed foods. Before July, glacier lily (Erythronium grandiflorum) would be available in the avalanche chute, mountain sidehill park, and burn shrubfield habitat components.

The mountain sidehill park component had the highest occurrence of biscuit-root of those components available before July. The slabrock component and the alpine complex component became available for digging activity in July. Western bistort (Polygonum bistortoides) was present in the subalpine cirque meadow and the slabrock components.

Comparisons During the Fruit Forage Season (August 1-Den Entry)

Table 6 shows vegetation type rankings for the fruit forage season. The subalpine fir/beargrass-globe huckleberry h.t. ranked the highest of all componments and vegetation types and was significantly greater in fruit-bearing taxa than the second-ranking terrestrial Picea VT (flood plain complex) (M-W p=0.06). There was also a significant difference in the second ranking terrestrial Picea VT and the third ranking subalpine zone burn VT (M-W p=0.06).

Globe huckleberry occurred in three of 28 vegetation types and in all three habitat types. The greatest cover of this food was in the subalpine fir/beargrass-globe huckleberry h.t. (table 7). Open-timbered stands of this habitat type were observed to have the greatest globe huckleberry fruit production of any vegetation type or habitat type. Such productive sites existed as stringers in the Xerophyllum tenax VT of the avalanche chute complex.

Serviceberry was widely distributed among habitat types and habitat components (table 7). The food item reached the highest percent cover and occurrence in the temperate zone burn VT; however, ungulate browsing pressure on this species during the winter appeared to be severe in this type.

The terrestrial Picea VT (flood plain benches) showed the highest observed cover of buffalo-berry (Shepherdia canadensis) of all types. Species of currant (Ribes spp.) and rose (Rosa spp.) had reached the greatest cover in several vegetation types in the riparian zone of the flood plain complex component.

Table 2.--Relationships among component availability, food categories, and foraging season

	Monthly availability[1] by foraging season						
	Herbaceous[2]			Fruit[3]			
Habitat component	May	June	July	Aug.	Sept.	Oct.	Nov.
Flood plain complex	X	X	X	X	X	X	X
Timbered creek bottom	X	X	X	X	X	X	X
Avalanche chute complex	X	X	X	X	X	X	X
Mountain sidehill park	X	X	X	X	X	X	X
Open burn shrubfield:							
Temperate zone	X	X	X	X	X	X	X
Subalpine zone			X	X	X	X	X
Timbered habitat types[4]				X	X	X	X
Subalpine cirque meadow			X	X	X	X	X
Slabrock			X	X	X	X	X
Alpine complex			X	X	X	X	

[1]Availability refers only to snow-free months.
[2]Vegetation, modified stems.
[3]Modified stems, fruit, pine nuts.
[4]Habitat types were not evaluated for herbaceous foraging season.

Table 3.--Vegetation type rankings for the herbaceous foraging season (highest ranking types only; den emergence to July 31)

Rank	Vegetation type	Habitat component	Vegetation type importance value	No. bear foods per preference rank 1	2	3	First month of availability
		VEGETATIVE FOOD CATEGORY					
1	Tallgrass/*Senecio triangularis*	Subalpine meadow	88	0	5	3	July
2	*Alnus* spp. shrubfield	Avalanche chute complex	61	2	3	6	May
3	Riparian *Picea*	Flood plain complex	54	1	4	7	May
4	Glade	Timbered creek bottom	40	3	5	8	May
5	Mesic herbaceous fan	Avalanche chute complex	40	4	3	6	May
6	Streamside	Avalanche chute complex	37	4	5	4	May
7	Mesic herbaceous meadow	Flood plain complex	36	1	2	8	May
8	Xeric herbaceous fan	Avalanche chute complex	32	3	1	5	May
9	*Xerophyllum tenax*	Avalanche chute complex	27	3	1	4	May
10	Closed timber	Timbered creek bottom	14	2	5	8	May
		MODIFIED STEM FOOD CATEGORY					
1	Sand bar	Flood plain complex	5	0	5	2	May
2		Slabrock	4	0	2	4	July
3	Mesic alpine meadow	Alpine complex	3	0	1	4	July
3	*Xerophyllum tenax*	Avalanche chute complex	3	0	2	4	May
3	Temperate zone burn shrubfield	Burn shrubfield	3	0	4	3	May

Table 4.--Coverage and occurrence of several "key" vegetative food items per vegetation type (percent cover/percent occurrence)

Habitat component	Vegetation type	*Heracleum lanatum*	*Angelica arguta*	*Ligusticum canbyi*	*Osmorhiza occidentalis*	Gramineae/ Cyperaceae	*Equisetum* spp.
Avalanche chute complex	Streamside	8/47	3/43	t/8[1]		8/100	
	Alnus shrubfield	8/52	1/10	1/14	1/15	3/72	
	Mesic herbaceous fan	4/40	1/18		1/36	26/100	
	Xerophyllum tenax	t/23	t/5		2/20	8/60	
	Xeric, warm aspect				t/8	30/100	
	Xeric herbaceous fan	t/9	t/6		5/38	21/81	
Flood plain complex	*Salix* flat	5/73	t/65	t/4	t/8	43/100	5/46
	Mesic herbaceous meadow	2/62	1/92		t/15	41/100	1/77
	Riparian *Picea*	1/63	t/56			15/100	2/59
	Populus trichocarpa	t/25	t/25			30/75	t/25
	Terrestrial *Picea*					7/100	
	Gravel bar					7/74	t/15
	Sand bar	t/7				4/69	
	Xeric graminoid meadow					26/100	
Timbered creek bottom	Glade	t/46	t/46			21/100	6/82
	Closed timber	1/48	2/40			24/100	1/53
Subalpine meadow	Tall grass/*Senecio triangularis*	4/31		2/35	7/50	26/100	
	Hydromesic			t/25		20/100	t/8
	Shortgrass/*Phyllodoce empetriformis* VT					49/100	t/4
Mountain sidehill park	Mixed graminoid					44/100	
	Xeric bunchgrass				t/2	10/90	
Burn shrub-field	Temperate zone		t/1			14/100	
	Subalpine zone		t/7			6/90	
Slabrock						16/100	
Alpine complex	Vegetated rock/talus					5/80	
	Fellfield					14/70	
	Mesic meadow					12/100	

[1] t=<0.5 percent cover.

Table 5.--Percent cover and occurrence of root, corm, and bulb food item per vegetation type (percent cover/percent occurrence)

Habitat component	Vegetation type	*Astragalus* spp.	*Oxytropus* spp.	*Erythronium grandiflorum*	*Polygonum bistortoides*	*Claytonia* spp.	*Hedysarum occidentale*	*Allium* spp.	*Lomatium* spp.
Flood plain complex	Xeric graminoid meadow							t/5	
	Mesic herbaceous meadow	t/23[1]						1/31	
	Sand bar	t/39	2/46					t/54	t/8
	Populus trichocarpa	1/75						t/50	
	Salix spp. flat	t/27						t/15	
	Terrestrial *Picea*	t/4						t/13	
	Riparian *Picea*	t/7						t/15	
	Gravel bar	t/26	t/4					t/4	
Avalanche chute complex	Mesic herbaceous fan								t/4
	Streamside			t/6			t/2		t/2
	Xeric, warm aspect	t/5		t/2					t/27
	Xerophyllum tenax	t/4		t/12			1/28		t/5
	Xeric herbaceous fan							t/6	
Mountain sidehill park	Mixed graminoid			t/12					t/24
	Xeric bunchgrass	t/2		t/32				t/4	t/24
Burn shrubfield	Temperate zone burn shrubfield	t/10		t/5			1/23	t/51	t/25
	Subalpine zone burn shrubfield	t/16		t/13			1/52		
Timbered creek bottom	Glade	t/4						t/8	
	Closed timber	t/11						t/21	
Subalpine meadow	Hydromesic herbaceous			t/17	t/71			t/71	
	Tallgrass/*Senecio triangularis*							t/22	
Slabrock		t/5		1/40	1/39	t/13		t/6	t/21
Alpine complex	Mesic meadow				t/52	t/12			1/48
	Vegetated rock/talus	t/16					t/3		1/32
	Fellfield	t/27							t/40

[1]t=<0.5 percent cover.

Table 6.--Vegetation type rankings for the fruit foraging season (highest ranking types only; August 1 to den entry)

Rank	Vegetation type or habitat type	Habitat component or forest habitat type	Vegetation type importance value	No. food items per preference rank 1	2	3
		FRUIT FOOD CATEGORY				
1	*Abies lasiocarpa/Xerophyllum tenax-Vaccinium globulare*	Forest habitat type	92	0	1	4
2	Terrestrial *Picea*	Flood plain complex	47	1	2	3
3	Subalpine zone burn shrubfield	Burn shrubfield	43	1	1	1
4	*Abies lasiocarpa/Luzula hitchcockii-Vaccinium scoparium*	Forest habitat type	38	0	1	2
5	Temperate zone burn shrubfield	Burn shrubfield	36	4	3	4
6	Xeric herbaceous fan	Avalanche chute complex	26	1	1	0
7	Mesic herbaceous meadow	Flood plain complex	25	5	1	3
8	*Populus trichocarpa*	Flood plain complex	25	2	1	2
9	Closed timber	Timbered creek bottom	16	6	3	2
10	Mixed graminoid	Mountain sidehill park	14	2	3	3
		MODIFIED STEM FOOD CATEGORY				
1	Sand bar	Flood plain complex	5	0	5	2
2		Slabrock	4	0	2	4
3	Mesic alpine meadow	Alpine complex	3	0	1	4
3	*Xerophyllum tenax*	Avalanche chute complex	3	0	2	4
3	Temperate zone burn shrubfield	Burn shrubfield	3	0	4	3

Table 7.--Cover and occurrence of "key" shrub food items (percent cover/percent occurrence)

Habitat component or habitat type	Vegetation type	*Vaccinium globulare*	*Amelanchier alnifolia*	*Vaccinium caespitosum*	*Cornus stolonifera*	*Shepherdia canadensis*	*Sorbus* spp.	*Rhamnus alnifolia*	*Vaccinium scoparium*	*Ribes* spp.	*Rosa* spp.
Flood plain	Xeric, graminoid meadow										t/5
	Mesic herbaceous opening		t/8[1]		2/15[1]	1/23				2/54	8/100
	Sand bar									t/15	3/62
	Populus tricho-carpa				24/75	2/75				t/25	1/100
	Salix flat		t/4			t/4		t/12		5/81	1/77
	Terrestrial *Picea*		t/17	41/91		91/13					t/4
	Riparian *Picea*				2/52	t/15				t/26	2/81
	Gravel bar										t/4
Avalanche chute complex	*Alnus* shrubfield						3/17	t/2		t/22	
	Mesic herbaceous fan			t/13			t/2		t/2	4/33	
	Streamside				t/1		1/8		t/2	3/10	
	Xeric, warm aspect		4/51	t/2			t/1		t/3		
	Xerophyllum tenax		1/26			t/2	1/6	t/1	4/21		
	Xeric herbaceous fan							18/28		3/19	
Burn shrubfield	Temperate zone		9/86		t/3	2/24	t/20		1/5	t/22	t/1
	Subalpine zone	3/13							16/100		t/3
Abies lasiocarpa/ *Xerophyllum globulare* habitat type		22/97	t/32			1/15	t/35				
Timbered creek bottom	Glade				6/21			t/4		1/57	t/29
	Closed	t/5		t/5	12/37					1/45	1/29
Abies lasiocarpa/ *Menziesia ferruginea* habitat type		t/92									
Mountain sidehill park	Mixed graminoid	t/6	2/71	t/6	2/6						t/18
	Xeric bunchgrass		1/20								
Subalpine meadow	Hydromesic								t/12		
	Shortgrass/ *Phylldoce empetriformis*								t/21		
Slabrock									2/19		
Alpine complex	Vegetated rock/talus								1/3		

[1] t=<0.5 percent cover.

Whitebark pine grew at elevations above 2 128 m. Grizzly bears seeking this food item would necessarily travel to habitats at or above this elevation.

DISCUSSION

The Habitat Component System

The habitat system described was developed in two field seasons. Although the major components and vegetation types were sampled and incorporated, expansion of the system would be possible.

Field reconnaissance and vegetation sampling suggested that although specific habitat components and their associated vegetation types could be extrapolated to other parts of the Bob Marshall Wilderness, the areal extent and juxtaposition of components and types could not be extrapolated. Ground reconnaissance and the literature (Habeck 1967; Johnson 1982) suggest that several precipitation zones are present in the Wilderness. The southern portion of the Wilderness is drier than northern portions adjacent to the Swan Range. Plant indicators of relatively moist habitats such as pachistima (Pachistima myrsinites) and queencup beadlily (Pfister and others 1977) were observed much less often in the southern study area than in Gorge, Statium, and Trickle Creeks in the northwestern portion of the Wilderness. If grizzly bear habitat quality is related to precipitation, population densities may be naturally variable within the Wilderness boundaries.

Those vegetation types that provided relatively high cover and occurrence values of key food items were considered superior to those types with lower values. This assumption was corroborated by grizzly bear investigations conducted in more open habitats, where study animals were easily observed. Stelmock (1981) stated that "habitat use during the summer was mainly confined to very specific vegetation types which provided dense cover of favored plant foods. Habitat use patterns closely followed the seasonal variations in quantity and quality of important foods."

Seasonal Ranking of Vegetation Types

The grizzly bear should be considered a "directed forager" because much of its habitat use patterns can be explained in terms of the presence of a few highly favored foods (Knight and others 1984). Thus only "key" grizzly bear foods obtained from the literature were used in the seasonal rankings. These rankings would place the grizzly bear in relatively high-quality habitat even if several unknown food items were not used in the analyses. Grasses and sedges were omitted from seasonal analyses because they tended to mask the importance of other foods, although grasses and sedges should be considered a staple food. Craighead and others (1982) theorized that grasses and sedges are more readily utilized because they are more available and abundant than other plant items.

Herbaceous foraging season.--Grizzly bears would find abundant succulent food plants in the flood plain complex, particularly in the riparian Picea VT and the mesic herbaceous meadow VT. The roots of yellow hedysarum (Hedysarum sulpherescens), however, are not likely an important food item in the study area because only one plant was observed. Such root-digging activity is important to grizzlies in the North Fork of the Flathead River (Singer 1978; McLellan 1982). Greater cover of crazyweed (Oxytropis spp.) was observed on the flood plain benches of the White River (northeast corner of the Bob Marshall) than in the core study area. No digging activity was observed in any flood plain complex types.

The observed quantity of plant foods in the avalanche chutes suggested that they would be an important spring and early component of habitat, especially the Alnus VT and the mesic herbaceous fan VT. The overall forage quality of the avalanche chute complex increased if the chute contained a stream course, was on a northern or western exposure, and was not dominated by a closed canopy of alder (Mace 1984).

Openings in the timbered creek bottoms of the study area (the glade VT) provided high cover values of horsetail, grasses and sedges, and several Umbelliferae. Creek bottom areas with a closed canopy were less productive than glades. It is probable, however, that preferred food items in these timbered sites would be relatively high in protein and moisture content for prolonged periods as compared to more open areas (Graham 1978).

The results of the less intensive alpine vegetation studies correlated well with those of Craighead and others (1982). Herbaceous foods were not abundant in the alpine complex but ranked high in foods that would be dug by grizzlies. No insect concentrations, known to be a summer source of food in several areas (Chapman and others 1953; Servheen 1981; Craighead and others 1982), were observed in the alpine complex of the study area.

Although whitebark pine nuts were not sampled specifically, grizzly bears would find them in abundance during years of good cone crops in the subalpine and alpine zones of the study area. Several scats of unknown bear species, collected in August, contained pine nuts; however, intense high-elevation burns could limit the availability of this food in certain areas, as whitebark pine does not mature for several decades following stand-replacing fire (Fischer and Clayton 1983).

Fruit foraging season.--Midelevation, open-timbered stands on southern exposures showed high fruit production of globe huckleberry. These productive sites often existed within large and south-facing avalanche chutes. Martin (1979)

stated that globe huckleberry is a late-seral or climax, meso-seral fruit producer.

Fruit production and cover values of buffalo-berry were relatively high on open to open-timber benches in the flood plain complex (terrestrial Picea VT). Conversely, virtually no dwarf huckleberry (Vaccinium ceaspitosum) fruit production was noted on these benches during the 2 years of study. Such bench land habitats are exceedingly important to grizzly bears occupying low-elevation areas during the autumn (McLellan 1982).

Those portions of the subalpine zone burns that occurred within the subalpine fir/beargrass-globe huckleberry h.t. showed relatively high cover of globe huckleberry. Burn shrubfields of the temperate zone were especially high in serviceberry cover values. All burns sampled in the temperate zone were of a Douglas-fir h.t. series and burned in 1926 (59 years ago).

Tisch (1961) found the subalpine fir/fool's huckleberry h.t. to be the most productive site for globe huckleberry in the Whitefish Range, MT. The lower cover values of this species in the Bob Marshall may reflect a small sample size (n=12) for this habitat type; however, such north-facing timbered sites appear to be important foraging habitats for grizzly bears during years of low rainfall (Mace and Jonkel 1980).

REFERENCES

Arno, S. F. Forest regions of Montana. Res. Pap. INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979. 39 p.

Arno, S. F. Forest fire history of the northern Rockies. J. For. 78(8): 460-465; 1980.

Aune, K.; Stivers, T. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1982. 143 p. Unpublished report.

Chapman, J. A.; Romer, I. J.; Stark, J. Ladybird beetles and army cutworm adults as food for grizzly bears in Montana. Ecology. 36: 156-158; 1953.

Craighead, J.; Sumner, J.; Scaggs, G. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Monograph 1. Missoula, MT: University of Montana, Wildlife-Wildlands Institute; 1982. 279 p.

Daubenmire, R. Structure and ecology of coniferous forests of the northern Rocky Mountains. In: Taber, R., ed. Coniferous forests of the northern Rocky Mountains. Missoula, MT: University of Montana, Center for Natural Resources; 1969: 25-41.

Deiss, C. Geology of the Bob Marshall Wilderness. In: Guide to the Bob Marshall Wilderness. Missoula, MT: U.S. Department of Agriculture, Forest Service; 1958. 36 p.

Fischer, W. C.; Clayton, B. D. Fire ecology of Montana forest habitat types east of the Continental Divide. Gen. Tech. Rep. INT-141. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 83 p.

Graham, D. C. Grizzly bear distribution, use of habitats and habitat characterization in Pelican and Hayden Valleys, Yellowstone National Park. Bozeman, MT: Montana State University; 1978. 88 p. M.S. thesis.

Habeck, J. The vegetation of Glacier National Park, Montana. Missoula, MT: University of Montana, Botany Department; 1967. 132 p.

Habeck, J.; Mutch, R. W. Fire-dependent forests in the northern Rocky Mountains. Quat. Res. 3(3): 408-424; 1973.

Hitchcock, C.; Cronquist, A. Flora of the Pacific Northwest. Seattle, WA: University of Washington Press; 1973. 730 p.

Johnson, T. W. An analysis of pack and saddle stock grazing areas in the Bob Marshall Wilderness Area, Montana. Bozeman, MT: Montana State University; 1982. 85 p. M.S. thesis.

Knight, R.; Mattson, D.; Blanchard, B. Movements and habitat use of the Yellowstone grizzly bear. Bozeman, MT: Inter-agency Grizzly Bear Study Team; 1984. Unpublished report.

McLellan, B. Akamina-Kishinena grizzly project progress report, year 3. Cranbrook, BC: British Columbia Fish and Wildlife Branch; 1982.

Mace, R. D. Identification and evaluation of grizzly bear habitat in the Bob Marshall Wilderness Area, Montana. Missoula, MT: University of Montana; 1984. 176 p. M.S. thesis.

Mace, R. D.; Jonkel, C. Grizzly bear response to habitat disturbance. Missoula, MT: University of Montana, Border Grizzly Project; Annual Report 5; 1980. 222 p. Unpublished report.

Mace, R. D.; Jonkel, C. Regional food habits of the grizzly bear in Montana. Paper delivered to the International Conference on Bear Research and Management. Grand Canyon, AZ, Feb. 18-22, 1983. In press.

Martin, P. Productivity and taxonomy of the Vaccinium globulare, V. membranaceum complex in western Montana. Missoula, MT: University of Montana; 1979. 136 p. M.S. thesis.

Mueller-Dombois, D.; Ellenberg, H. Aims and methods of vegetation ecology. New York: John Wiley and Sons; 1974. 547 p.

Nie, N.; Hull, C.; Steinbrenner, K.; Bent, D. Statistical package for the social sciences. New York: McGraw-Hill; 1975. 675 p.

Pfister, R.; Batchelor, R. F. Montana riparian vegetation types. Missoula, MT: Western Wildlands. 9(4): 19-23. 1984.

Pfister, R.; Kovalchik, B.; Arno, S.; Presby, R. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Russell, R. H.; Nolan, J. W.; Woody, N.; Anderson, G. A study of the grizzly bear in Banff National Park, 1975-78. Final Report prepared for Parks Canada. Edmonton, AB: Canadian Wildlife Service; 1979. 136 p.

Servheen, C. Grizzly bear ecology and management in the Mission Mountains, Montana. Missoula, MT: University of Montana; 1981. 138 p. Dissertation.

Singer, F. J. Seasonal concentrations of grizzly bears, North Fork of the Flathead River, Montana. Canadian Field-Nat. 92(3): 283-286; 1978.

Steele, R. The role of fire in the Bob Marshall Wilderness Area, Montana. Missoula, MT: Forest and Conservation Experiment Station; 1960. 33 p.

Stelmock, B. S. Seasonal activities and habitat use patterns of brown bears in Denali National Park-1980. Fairbanks, AK: University of Alaska; 1981. 118 p. M.S. thesis.

Sumner, J.; Craighead, J. Grizzly bear habitat survey in the Scapegoat Wilderness, Montana. Missoula, MT: University of Montana, Montana Cooperative Wildlife Research Unit; 1973. 49 p.

Tisch, E. Seasonal food habits of the black bear in the Whitefish Range of northwestern Montana. Missoula, MT: Montana State University; 1961. 108 p.

U.S. Department of Agriculture. Valley bottomland inventories with management implications; working draft. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region; 1978. 14 p. Mimeo.

U.S. Department of the Interior. Grizzly bear recovery plan. Denver, CO: U.S. Department of the Interior, Fish and Wildlife Service; 1982. 195 p.

Zager, P.; Jonkel, C.; Mace, R. D. Grizzly bear habitat terminology. Special Report 41. Missoula, MT: University of Montana, Border Grizzly Project; 1980. 13 p. Unpublished report.

GRIZZLY BEAR HABITAT USE, FOOD HABITS, AND MOVEMENTS IN THE SELKIRK MOUNTAINS, NORTHERN IDAHO

Jon A. Almack

ABSTRACT: Grizzly bear (Ursus arctos horribilis) habitat in the Selkirk Mountains of northern Idaho was evaluated during 1983 and 1984. Habitat use, feeding habits, and movements of one adult female grizzly bear were investigated. Twenty habitat component classes were identified for analysis. Forb and shrub seral stages of a large, 18-year-old burn were used more than expected by chance ($P < 0.10$). Timbered components and recent cutting units were used less than expected. Food items were identified by scat analysis and direct observation of foraging grizzly bears. Eight previously undocumented food items were identified. Daily linear movements averaged 3.0 km, ranging from virtually no movement for a period of 3 weeks before denning to a long-distance trek of 45.7 km in an 18-hour period. Annual home ranges for 1983 and 1984 measured 195 km^2 and 609 km^2, respectively.

INTRODUCTION

Grizzly bears occur throughout the Selkirk Mountains of northern Idaho and northeastern Washington; however, data from the Selkirk Mountains Grizzly Bear Ecosystem (SMGBE) have been insufficient to allow the estimation of population parameters, habitat requirements, and accurate delineation of grizzly bear range (USDI 1982). Wright (1909) first documented the presence of this population in his historical account of hunting treks into the Selkirk range. Sutliff (1933) also chronicled a Selkirk grizzly bear hunt, noting a spring concentration of bears in the area. The most recent known kill occurred illegally near Priest River in 1983.

Scientific review of the Selkirk population was virtually absent until Layser's (1972, 1978) discussions of confirmed observations and sign. Zager (1981, 1983) conducted a habitat survey of the SMGBE to determine if grizzly bear habitat components and foods were present and capable of supporting a viable grizzly bear population.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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To obtain additional information on the Selkirk grizzly bear population and its habitat, Idaho Department of Fish and Game, Washington Department of Game, USDA Forest Service, USDI Fish and Wildlife Service, Idaho Cooperative Wildlife Research Unit, University of Idaho, and British Columbia Fish and Wildlife Branch provided funding and materiel support for a 2-year research project. The objectives of the study were to determine seasonal grizzly bear habitat use, identify seasonal food habits, determine individual home ranges, and delineate population distribution.

STUDY AREA

The SMGBE includes the southern portion of the Selkirk range in Washington and Idaho, encompassing approximately 2 590 km^2 (fig. 1). The rugged, bedrock-exposed landscape is covered by a mosaic of dense coniferous forest, old burns, and cutting units. Elevations range from 518 m to just above 2 330 m. Precipitation ranges from 85 to 95 cm annually; snow depths average 1 to 6 m. Timber management dominates the area; virtually the entire SMGBE falls under Forest Service and Idaho Department of Lands administration.

METHODS

By combining over 220 habitat component complexes mapped by the Forest Service in 1983 and 1984, I identified 20 component classes for analysis:

Habitat component	Description
A Alder shrubfield	Dense shrubfield dominated by alder with Rocky Mountain maple. Canopy cover 80 + percent.
B Mixed shrubfield burn	Open shrubfield dominated by mix of huckleberry, elderberry, fool's huckleberry, mountain-ash. Canopy cover 30 to 50 percent.
C Mixed shrubfield snowchute	Dense shrubfield dominated by mix of species with cover to 100 percent. Maintained by violent, infrequent snow avalanches.

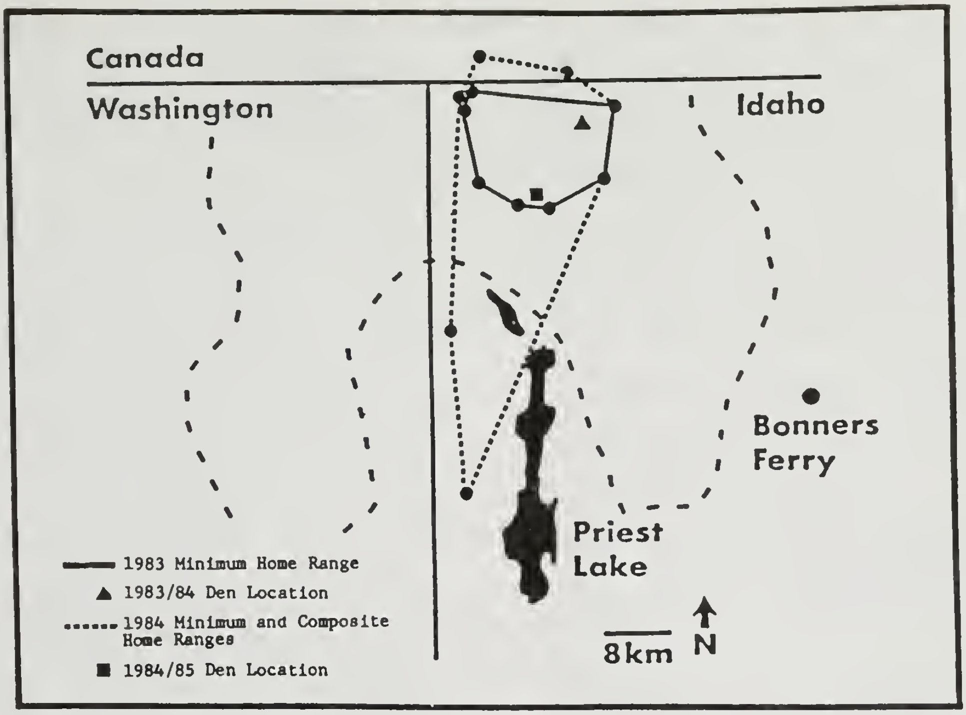

Figure 1.--1983 and 1984 minimum home ranges for grizzly bear U867. The 1983 range (195 m^2) included period from June 4 capture to November 5 den entry. The 1984 range (609 km^2) included period from April 22 den emergence to November 5 den entry.

Habitat component		Description
D	Drainage forbfield	Small, succulent forbfield at base of rock outcrops, cirque headwalls, and moraines. Maintained by snowmelt and rain drainage off of rock.
E	Timbered mixed shrubfield	Shrub-dominated understory with tree canopy of 30 to 60 percent.
EE	Forbfield burn	Early seral forb stage following natural fire.
F	Forbfield cutting unit	Early seral forb stage following timber harvest.
FF	Open-timbered grass	Grass-dominated understory with tree canopy 30 to 60 percent.
G	Grass sidehill park	Open, grass-dominated park; often along ridges or on upper slopes.
H	Mixed shrubfield	Shrubfield with <30 percent tree canopy codominated by mix of shrubs.
K	Rock	Nonvegetated rock, slabrock, talus, scree, boulders, cliffs, outcrops.
M	Marsh	Sedge-dominated with slow-moving or standing water.
NC	New cutting unit	Recent timber harvest site with little or no vegetation regeneration.
R	Riparian stream-bottom	Lush growth along streams; includes open and timbered sites.
U	Mixed shrubfield	Mixed species seral shrub cutting unit stage following timber harvest.
V	Huckleberry shrubfield	Shrubfield dominated by canopy of >40 percent huckleberry, <30 percent tree cover.
W	Wet meadow	Grass- and sedge-codominated meadow.
X	Beargrass sidehill park	Open, beargrass-dominated park; often along ridgetops or on upper slopes.
Z	Dry meadow	Open, grass-dominated meadow; often created by physical disturbance.
O	Closed timber	Tree-dominated site with canopy >60 percent.

Table 1.--Interpretation of habitat component use versus availability results for grizzly bear U867[1]

Habitat component	Habitat use[2] Spring	Summer	Fall	Total
Alder shrubfield	<	<	=	=
Mixed shrubfield burn	=	>	=	>
Mixed shrubfield snowchute	=	=	=	=
Drainage forbfield	=	=	=	=
Timbered mixed shrubfield	=	<	<	<
Forbfield burn	=	>	<	>
Forbfield cutting unit	<	=	=	=
Open-timbered grass	<	<	<	<
Grass sidehill park	=	=	<	=
Mixed shrubfield	=	=	=	=
Rock	=	=	=	=
Marsh	=	=	=	=
New cutting unit	<	<	<	<
Riparian streambottom	<	=	=	=
Mixed shrubfield cutting unit	=	=	=	=
Huckleberry shrubfield	=	=	<	=
Wet meadow	=	=	=	=
Beargrass sidehill park	<	=	=	=
Dry meadow	<	=	=	=
Closed timber	<	<	=	<

[1]N (use) = 272 radio locations.
N (availability) = 307 random locations.
[2]Habitat use symbols:
< Use significantly less than availability ($P < 0.10$).
> Use significantly greater than availability ($P < 0.10$).
= No significant difference detected between use and availability ($P > 0.10$).

Studies in the SMGBE (Zager 1981; Demers 1983; Robinson and Riley 1984) and Montana (Jonkel 1982; Christensen and Madel 1982) provided general descriptions of each habitat component class (Almack 1985).

Using these classes as a framework, I obtained baseline habitat use data for the SMGBE from daily radio monitoring and direct observation of an adult, female grizzly bear (U867). I followed the sampling design and analyses presented by Marcum and Loftsgaarden (1980). This method identifies the number of radio and random locations found in each habitat component class within the composite home range. Proportions of seasonal habitat use (radio locations) and availability (random locations) are then compared by analysis of chi-square ($P < 0.05$) and modified Bonferroni z ($P < 0.10$) statistics. Spring availability proportions may be slightly inflated, due to variable snow cover of components at higher elevations.

Distances from all 272 radio locations and 307 random locations measured to the nearest different habitat component, water, road, and trail provided further habitat use information. I grouped distance measurements into three classes: close (< 100 m), mid (100-500 m), and far (> 500 m).

Scat analysis and direct observation of foraging grizzly bears provided data for a partial list of grizzly bear food items. Differentiation of scats by bear species followed the methods of Hamer and Herrero (1980), excluding diameter and amorphous volume as positive identifiers. I classified a scat as "grizzly bear" only when I saw the scat dropped or found the scat at a visual observation site or close-distance radio location, where other direct evidence of grizzly bear activity was apparent.

I determined the length of daily movements for the radio-collared female by measuring linear distances on a map (Mech 1983). Delineation of her 1983 and 1984 home ranges followed the procedures described by Mohr (1947). Area polygons formed by 272 independent radio locations depicted minimum annual and composite home ranges (Russell and others 1979).

RESULTS AND DISCUSSION

Habitat Use

I rejected the null hypothesis that U867 used habitat components in proportion to their availability. Both total and seasonal comparisons showed significant differences between component use and availability ($P < 0.05$) (table 1).

Overall, U867 used mixed shrubfield burn and forbfield burn habitat components significantly more than expected (P < 0.10). She used timbered mixed shrubfield, open-timbered grass, new cutting unit, and closed timber components less than expected (P < 0.10).

Studies have indicated that grizzly bear spring range is often limited by prevailing snow cover and minimal plant productivity during early phenological stages (Jonkel 1982; Craighead and Mitchell 1983). Therefore, I anticipated use of important spring components, such as wet meadows, marshes, and snowchutes, to be greater than their availability. However, U867 used no component more than expected during spring. No significant differences (P > 0.10) were indicated between use and availability proportions for mixed shrubfield burn, mixed shrubfield snowchute, drainage forbfield, forbfield burn, grass sidehill park, mixed shrubfield, rock, marsh, mixed shrubfield cutting unit, huckleberry (*Vaccinium* spp.) shrubfield, and wet meadow habitat components. She used alder (*Alnus* sp.) shrubfield, forbfield cutting unit, open-timbered grass, new cutting unit, riparian streambottom, beargrass (*Xerophyllum tenax*) sidehill park, dry meadow, and closed timber components less than expected (P < 0.10).

Summer results closely paralleled field observations. Mixed shrubfield burn and forbfield burn habitat components showed greater use than expected during summer (P < 0.10). U867 often used burn components to the near exclusion of other classes, feeding nearly 50 hours on huckleberry and elderberry (*Sambucus racemosa*). She used alder shrubfield, timbered mixed shrubfield, open-timbered grass, new cutting unit, and closed timber components less than expected (P < 0.10).

U867 used no fall component more than expected (P > 0.10). She used timbered mixed shrubfield, forbfield burn, open-timbered grass, grass sidehill park, new cutting unit, and huckleberry shrubfield components less than expected (P < 0.10).

Field observations indicated a shift from summer to fall component use. She fed on grass and forb roots in clearcuts and selection cuts during October each year; however, cutting units did not show more fall use than expected (P > 0.10). During this same period, daily activity decreased to a predenning lethargy phase. This inactive period may have overshadowed apparent heavy use of cutting units in early fall.

Sixty-three percent of the total radio locations fell within 100 m of the nearest habitat component. Similar results were noted for seasonal measurements. Of the total number of radio locations, 68 percent occurred nearest to timber and shrubfield components. U867 may have selected these sites for the security cover provided by the dense vegetation (Zager 1980; Jonkel 1982).

U867 remained near water more than expected by chance (P < 0.05), with 27 percent of her total radio locations within 100 m of water and 79 percent within 500 m (table 2). Seasonal analyses failed to show significant differences between the use and availability of water distance classes (P > 0.10).

The distribution of water did not appear to limit her use of any area. Perhaps this analysis indicates a preference for moist site foods, or the abundance of moist sites, rather than a direct water requirement.

No significant differences (P > 0.10) were noted between distances measured to roads from radio and random locations. Sixty-four percent of the total radio locations occurred in the > 500-m distance class. Seasonal results varied for each road distance class (table 2). These data result from the distribution of the road system in the SMGBE. At least one road penetrates each major drainage in U867's composite home range; however, seasonal activity centered in areas of low road density.

Total and summer analyses of distance to nearest trail data indicated greater than expected use of the < 100-m and 100- to 500-m classes (P < 0.10) (table 2). The > 500-m distance class was used less than expected for these two periods (P < 0.10). Spring and fall results failed to show significant differences between the use and availability of trail distance classes (P > 0.10). Few maintained trails occurred within U867's composite home range, hence the large number of radio locations in the > 500-m distance class. Many of the trails documented for this analysis are actually overgrown fire access roads showing continued use as game trails.

Food Habits

The food habits of U867 were similar to those of grizzly bears in other ecosystems; however, I recorded eight food items undocumented in other study areas:

Species	Structures observed[1]
Direct observation food items	
Camponotus sp. ants	E
Carex spp.	Fl, Lvs
Equisetum arvense	Fl, St
Formica sp. ants	E
Graminoid spp.	Fl, Lvs, R
Gymnocarpium dryopteris	Lvs
Heracleum lanatum	St
Luzula hitchcockii[2]	Fl, Lvs, R, St
Sambucus racemosa	Fr
Streptopus amplexifolius[2]	Lvs, St
Taraxacum officinale	Lvs, St
Trifolium repens	Fl, Lvs, St
Trillium ovatum[2]	Fl, St
Vaccinium spp.	Fr, Lvs, St

Table 2.--Interpretation of seasonal distance class use versus availability for grizzly bear U867[1]

Distance to nearest:	Distance class use[2] Close < 100 m	Mid 100-500 m	Far > 500 m
Water			
Spring	=	=	=
Summer	=	=	=
Fall	=	=	<
Class total	>	=	=
Road			
Spring	=	<	=
Summer	=	=	=
Fall	=	>	=
Class total	=	=	=
Trail			
Spring	=	=	=
Summer	>	>	<
Fall	=	=	=
Class total	>	>	<

[1]N (use) = 272 radio locations.
Spring = 62 radio locations.
Summer = 132 radio locations.
Fall = 78 radio locations.
N (availability) = 307 random locations.

[2]Distance class symbols:
< Use significantly less than availability ($P < 0.10$).
> Use significantly greater than availability ($P < 0.10$).
= No significant difference detected between use and availability ($P > 0.10$).

Species	Structures observed[1]
Dig food items	
Angelica arguta[2]	R
Claytonia lanceolata	R
Clintonia uniflora[2]	R
Erythronium grandiflorum	Fl, R, St
Graminoid spp.	R
Lomatium sp.	R
Mitella breweri[2]	R
Osmorhiza spp.	R, St
Sambucus racemosa	R
Spermophilus columbianus	E
Tiarella trifoliata[2]	R, St
Viola glabella[2]	Lvs, R, St

The analysis of 234 scats and direct observation of foraging grizzly bears provided food lists for the SMGBE (table 3).

[1]E = entire organism
Fl = flower
Fr = fruit
Lvs = leaves
R = root
St = stem.

[2]Food item not noted in literature.

During spring, U867 fed on sedges (*Carex* spp.), horsetail (*Equisetum* spp.), clover (*Trifolium* spp.), grasses, and roots of western spring beauty (*Claytonia lanceolata*), glacier lily (*Erythronium grandiflorum*), and biscuit-root (*Lomatium* spp.). She used wet meadows, marshes, and moist cirque basins extensively during this season.

She fed in mixed shrubfields of a large burn during summer. Huckleberry and elderberry fruits, horsetail, licorice-root (*Ligusticum* spp.), and ants (*Camponotus* sp., *Formica* sp.) were common food items. Shrub fruits dominated her summer diet, although at times she fed almost exclusively on forbs and grasses.

During fall in 1983, U867 dug in old (greater than 2 years) clearcuts and selection cuts for roots of grasses, Brewer's mitella (*Mitella breweri*), and coolwort foamflower (*Tiarella trifoliata*). However, in 1984, she excavated cutting units exclusively for roots of first-season growth elderberry and desiccated sweet-cicely (*Osmorhiza* spp.). She also clawed and rolled logs for ants and earthworms (Class Oligochaeta).

Table 3.--Grizzly bear food items identified by scat analysis (N = 34 scats)

Species	Constancy	Structures observed[1]
	Percent	
Shrubs	10.6	
Lonicera sp.	5.9	Lvs, R
Oplopanax horridum	5.9	Fr, S
Sambucus racemosa	5.9	Lvs, R, St
Vaccinium membranaceum	41.2	Fr, Lvs, S, St
Vaccinium scoparium	8.8	Lvs, S
Vaccinium spp.	20.6	Lvs, S, St
Forbs/ferns	60.0	
Equisetum spp.	55.9	St
Ligusticum canbyi	17.6	Lvs
Ligusticum sp.	23.5	Lvs
Lomatium sp.	11.8	Lvs
Osmorhiza chilensis	5.9	Lvs, R, St
Osmorhiza sp.	17.6	Lvs, St
Streptopus amplexifolius	5.9	Fr, S
Trifolium sp.	8.8	Fl, Lvs, St
Unknown fern sp.	2.9	Lvs
Unknown seed	5.9	S
Grass/grasslikes	16.2	
Carex sp.	38.2	Fl, Lvs
Graminoid spp.	85.3	Fl, Lvs, R, St
Luzula hitchcockii	11.8	Lvs, R (?)
Animal	15.2	
Camponotus sp. ant	11.8	E
Formica sp. ant	17.6	E
Odocoileus sp.	5.9	B, H, Hf
Spermophilus columbianus	11.8	B, C, H, T
Ursus americanus	2.9	H
Ursus arctos	20.6	H
Unknown sp. beetle	5.9	E, L, W
Unknown sp. bone	5.9	
Unknown sp. hair	8.8	
Unknown sp. insect wing	2.9	
Unknown sp. worm	2.9	

[1]B = bone
C = claw
E = entire organism
Fl = flower
Fr = fruit
H = hair
Hf = hoof
L = leg
Lvs = leaves
R = root
S = seed
St = stem
T = teeth
W = wing.

Dens

In 1983, U867 denned in a northeast-facing, natural rock cave at 1 902 m. The cave measured 9.4 m deep and opened at the base of a rock outcrop that protruded into a timbered mixed shrubfield. The entrance measured 86 cm wide and about 80 cm high.

She used white rhododendron (Rhododendron albiflorum) and fool's huckleberry (Menziesia ferruginea) stems to form a nest located about 5.4 m from the entrance and measuring 1.6 m in diameter. The nest site had apparently been used before, as evidenced by 30 cm of decayed shrub stems and beargrass leaves that lay under the most recent nest material.

I found two scats behind the nest. Both scats were moldy and densely compacted; each contained grizzly bear guard hairs and smooth woodrush (Luzula hitchcockii) leaves.

A rock shelf, 1.1 m wide, extended for about 7.6 m in front of the den. A natural mat of soil and smooth woodrush covered the shelf and extended down slope into a timbered mixed shrubfield of white rhododendron, fool's huckleberry, and huckleberry. U867 had chewed off many of these shrubs, leaving only 10 to 15 cm of the stems remaining above ground. I found chewed shrubs up to 21 m from the den. Five daybeds were located on this shelf, and several trees showed deep claw marks to a height of about 2.5 m.

In 1984, U867 also denned in a natural, rock cave. The den lay between two active snowchutes at 1 890 m on the northeast-facing headwall of an east-facing cirque basin. The cave opened at the base of a rock outcrop in a mixed shrubfield/rock habitat component complex. The entrance was very exposed and measured 133 cm high and 90 cm wide.

The nest measured 137 cm in diameter and was located at the rear of the cave. Chewed stems of mountain-ash (Sorbus spp.) and huckleberry, along with leaves of smooth woodrush and sedge, served as nest material. Most of this material had been scraped from the nest and swept out of the den. I found only three shrubs near the den that showed any evidence of chewed stems.

I found three small scats just inside the cave. They were not densely compacted, as were the 1983-1984 den scats. All three scats contained unidentified vegetal debris.

Den entry both years occurred on November 5. Den emergence was on April 22, 1984, and during the week of May 10, 1985.

Daybeds

I located 10 grizzly bear daybeds in the SMGBE; eight of these belonged to U867. Daybed No. 1 lay under a lone, mature subalpine fir (Abies lasiocarpa) within a grass sidehill park. I located two scats within 1 m of the bed. Both scats measured approximately 8 cm in diameter and

3 L in volume. Each scat contained over 90 percent grass and a trace of licorice-root leaves.

U867 located Daybed No. 2 next to an uprooted stump, associated with ground squirrel (Spermophilus columbianus) digs in a mixed shrubfield burn. This bed measured about 82 cm in diameter and 76 cm deep and contained four alternated layers of loose soil and grass leaves. Radio telemetry indicated that she used this site several times, perhaps adding a fresh layer of soil and grass for each occupancy.

Daybeds No. 3 to 7 lay on the shelf in front of her 1983-1984 cave den. Each bed measured about 90 cm in diameter. Twigs of white rhododendron and fool's huckleberry lined two of the beds; the others lay directly on a mat of smooth woodrush. I cannot document when she used these daybeds.

Craighead and Craighead (1972a, 1972b) and Craighead (1979) noted grizzly bear use of daybeds at the den site immediately prior to denning. Servheen (1981) observed similar use of den site daybeds. He also postulated that grizzly bears may use dens and associated daybeds during the summer to escape daytime heat, which may be the case here. During this July examination, ambient temperatures differed from 6.7 °C in the cave, to 20.0 °C on the shelf outside.

U867 used two daybeds immediately before denning in 1984. After feeding in a clearcut about 100 m down slope, she located Daybed No. 8 on the edge of a small alder shrubfield. She remained in this south-facing bed during a severe overnight snowstorm. The unlined bed lay between two naturally exposed roots on the uphill side of a large Engelmann spruce (Picea engelmannii). A scat packed with sweet-cicely and elderberry roots lay about 5 m from the bed.

She remained at Daybed No. 9 for 15 days, until moving to her den. This bed lay on a natural mat of sedges against the uphill side of a large mountain hemlock (Tsuga mertensiana). Snow measured about 1 m at the bed site. No scats or evidence of feeding were noted near the bed.

Daybed No. 10 lay about 0.5 m from the entrance to her 1984-1985 cave den. Measuring 50 cm in diameter and formed on a natural mat of smooth woodrush, the bed covered the top of a flat boulder. I found no scats near this daybed, but I noted extensive digs for glacier lily within 10 m of the site.

Movements

The mean daily linear movement for U867 measured 3.0 km. Daily movements ranged from 0 to 45.7 km, including periods of virtually no movement before denning and one long trek of 45.7 km to a feeding site. Seasonally, her daily movements averaged 2.8 km for spring, 3.7 km for summer, and 2.4 km for fall, with no significant differences noted ($P > 0.05$). Almack (1985) described several individual movements in detail.

Radio location analysis showed no significant differences in seasonal use of aspects ($P > 0.05$). She remained between 1 400 and 1 700 m elevation, except during May, when she was located at 850 m for about 7 days.

Home Range

Annual home ranges for U867 during 1983 and 1984 measured 195 and 609 km^2, respectively (fig. 1). Her composite home range duplicated the 1984 annual range.

The composite range measured larger than those calculated for most females in other study areas. Both Servheen (1981) and Jonkel (1982) reported female home ranges in northwestern Montana varying from 15 to 136 km^2. Aune and Stivers (1982) reported female ranges from 31 to 450 km^2 on the Rocky Mountain Front in north-central Montana. In Canada, Russell and others (1979) reported several large female home ranges from Jasper National Park; the largest of these measured 532 km^2. One of the largest female home ranges, documented in Yellowstone National Park by Knight and Blanchard (1983), measured approximately 900 km^2.

Russell and others (1979) postulated that a young female (4 to 9 years old) may explore a larger home range to optimize her chances for breeding and to locate a "core range" suitable for rearing cubs. This idea provides a plausible explanation for the size of U867's 1984 home range.

All of her long-distance movements (> 15 km), with the exception of fall movements to den sites and summer movements resulting from human disturbance, occurred from late May to late June, during the breeding season. She also used a much smaller area during summer and fall in 1984.

This smaller "core" area contained approximately 65 percent of her radio locations and measured about 45 km^2. Mostly located within a large burn, this area contained a rich food supply, consisting of productive forbfields, huckleberry and elderberry shrubfields, and an abundance of ground squirrels, marmots (Marmota caligata), and ants. She emerged from her 1984-1985 den about May 13 with two cubs.

REFERENCES

Almack, J. A. An evaluation of grizzly bear habitat in the Selkirk Mountains of north Idaho. Moscow, ID: University of Idaho; 1985. 87 p. M.S. thesis.

Aune, K.; Stivers, T. Rocky Mountain Front grizzly bear monitoring and investigation. Cooperative report of Montana Department of Fish, Wildlife and Parks. Helena, MT; 1982. 143 p.

Christensen, A. G.; Madel, M. J. Cumulative effects analysis process; grizzly habitat component mapping. Libby, MT: USDA Forest Service, Kootenai National Forest; 1982. 38 p.

Craighead, F. C., Jr. Track of the grizzly. San Francisco, CA: Sierra Club Books; 1979. 261 p.

Craighead, F. C., Jr.; Craighead, J. J. Grizzly bear prehibernation and denning activities as determined by radiotracking. Wildl. Monogr. No. 32; 1972a. 35 p.

Craighead, F. C., Jr.; Craighead, J. J. Data on grizzly bear denning activities and behavior obtained by using wildlife telemetry. In: Herrero, S., ed. Bears--their biology and management. IUCN Publication, New Series No. 23. Morges, Switzerland: International Union of Conservation Nations; 1972b: 84-106.

Craighead, J. J.; Mitchell, J. A. Grizzly bear (Ursus arctos). In: Chapman, J. A.; Feldhamer, G. A., eds. Wild mammals of North America: biology, management, and economics. Baltimore, MD: The Johns Hopkins University Press; 1983: 515-556.

Demers, D. Methods for delineation of grizzly bear habitat components on the Sullivan Lake Ranger District, Colville National Forest. 1983. Unpublished report on file at: USDA Forest Service, Colville National Forest, Colville, WA. 19 p.

Hamer, D.; Herrero, S. Differentiating black and grizzly bear faeces. National Research Council of Canada, Grant #A-6507. Calgary, AB: University of Calgary; 1980. 8 p.

Idaho Department of Fish and Game. All around Idaho. In: Idaho Wildlife Review, 1973 March-April: 16.

Jonkel, C. J. Five year summary report. Border Grizzly Project Special Report No. 60. Missoula, MT: University of Montana, School of Forestry; 1982. 277 p.

Knight, R. R.; Blanchard, B. M. Yellowstone grizzly bear investigations. Report of the Interagency Study Team, 1982. Yellowstone National Park, WY: USDI National Park Service; 1983. 45 p.

Layser, E. F. Grizzly bears in the southern Selkirk Mountains. Northwest Sci. 52: 77-91; 1978.

Layser, E. F. Notes on grizzly bear sightings in northeastern Washington and adjacent northern Idaho. Murrelet. 53: 8-9; 1972.

Marcum, D. L.; Loftsgaarden, D. O. A nonmapping technique for studying habitat preferences. J. Wildl. Manage. 44: 963-968; 1980.

Mech, L. D. Handbook of animal radio-tracking. Minneapolis, MN: University of Minnesota Press; 1983. 108 p.

Mohr, C. O. Table of equivalent populations of North American small mammals. Amer. Midl. Nat. 37: 223-249; 1947.

Robinson, K.; Riley, D. Grizzly bear habitat component mapping; Selkirk ecosystem. Priest Lake, ID: USDA Forest Service, Idaho Panhandle National Forests, Priest Lake Ranger District; 1984. 19 p.

Russell, R. H.; Nolan, J. W.; Nagy, N. G.; Anderson, G. H. A study of the grizzly bear in Jasper National Park 1975 to 1978. Final Report. Edmonton, AB: Canadian Wildlife Service; 1979. 136 p.

Servheen, C. Grizzly bear ecology and management in the Mission Mountains, Montana. Missoula, MT: University of Montana; 1981. 139 p. Ph.D. dissertation.

Sutliff, C. B. Charging death; the true account of a grizzly hunt that almost ended fatally. Outdoor Life. 1933 February: 15-17, 48-50.

U.S. Department of the Interior. Grizzly bear recovery plan. Washington, DC: USDI Fish and Wildlife Service; 1982. 195 p.

Wright, W. H. The grizzly bear. New York: Charles Scribner's Sons; 1909. 274 p.

Zager, P. E. Grizzly bears in Idaho's Selkirk Mountains: an update. Northwest Sci. 57: 299-309; 1983.

Zager, P. E. Northern Selkirk Mountains grizzly bear habitat survey, 1981. New Concord, OH: Muskingum College; 1981. 75 p.

Zager, P. E. The influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Missoula, MT: University of Montana; 1980. 131 p. Ph.D. dissertation.

THE SELWAY-BITTERROOT ECOSYSTEM AS GRIZZLY BEAR HABITAT

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ABSTRACT: The Selway-Bitterroot Grizzly Bear Ecosystem (SBGBE) is one area described by the Grizzly Bear Recovery Plan as suitable for reestablishing a viable grizzly bear population. Historical evidence indicates that the area once was occupied by grizzly bears with the last confirmed report in 1956. Factors that may have been responsible for the virtual disappearance of the bear are discussed. Management recommendations for the SBGBE are also suggested.

INTRODUCTION

The Grizzly Bear Recovery Plan describes an area centered around the Selway-Bitterroot Wilderness as suitable for recovering a viable grizzly bear (Ursus arctos horribilis) population (U.S. Department of the Interior, Fish and Wildlife Service, 1982). This undefined area is referred to as the Selway-Bitterroot Grizzly Bear Ecosystem (SBGBE). Of the six ecosystems identified in the Plan, the SBGBE received one of the lowest priorities because (1) the area had little or no baseline data on grizzly bear populations or habitat, (2) potential conflicts due to land development would be minimal because most of the area is wilderness, (3) personnel and dollars were limited and it would require excessive expenditures to bring the data base up to par. For these reasons, the Plan did not identify recovery goals and occupied habitat for the area.

A recovery plan goal for the SBGBE was to secure, maintain, or reestablish a viable population of grizzly bears. Specific objectives were to (1) determine the present status of the grizzly bear population, (2) determine the space and habitat necessary to support a viable population, and (3) define the appropriate actions necessary to develop a more refined recovery plan. The U.S. Department of Agriculture, Forest Service, in cooperation with the Idaho Department of Fish and Game and Montana Department of Fish, Wildlife, and Parks, was given the lead responsibility for funding and meeting the specific objectives.

The purpose of this paper is to document reports of grizzly bear observations on the SBGBE and to evaluate and discuss grizzly bear habitat and conditions.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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DESCRIPTION OF THE AREA

The SBGBE is approximately 60 miles southwest of Missoula, MT, in north-central Idaho (fig. 1). It is surrounded by lands managed by the Clearwater, Nezperce, and Bitterroot National Forests. An extensive trail system provides access within the Wilderness. Potential grizzly bear habitat within the three National Forests is remote and undeveloped. Topography is rugged, with elevations ranging from 2,000 to 10,000 ft. Glaciers moved through most of the area, leaving many deep, U-shaped valleys. Alpine meadows and cirque lakes are common. The mountains within this area consist of a granite rock representing the northern extension of the Idaho Batholith (Lindgren 1904). Coniferous vegetation is interrupted by a mosaic of extensive granite slabs, boulder fields, talus slopes, meadows, and avalanche chutes. The geology, geography, climate, and soils of this area have been described (Arno 1970; Lackschewitz 1970; Habeck 1972; and Smith 1976).

Figure 1.--Geographical location of the Selway-Bitterroot Wilderness, ID.

The climate varies considerably but can be generally described as humid or simihumid. The average annual precipitation at 3,000 ft is 43 inches and occurs primarily as snowfall from October through June. Rainfall is common in late spring and early summer, usually decreasing to near drought conditions in July and August. At higher elevations and on northerly slopes, snowpack may remain well into late summer.

DISCUSSION

Historical Perspective

Lewis and Clark were the first explorers to contribute factual information about the grizzly bear and its habitat in Idaho (Burroughs 1961; Layser and others 1979). Expedition members reportedly killed six grizzlies in the Clearwater Valley near Kamiah in 1806. Wright (1909), a skilled hunter and naturalist, found that the bears were relatively common in the Clearwater area in the 1890's. During one episode he reported killing five grizzly bears on the Clearwater. On another occasion, late in the fall of 1981, two hunters from Spokane killed 13 grizzlies during a single bear hunt in the "Bitterroot region."

Merriam (1922) defined the boundaries of grizzly bear range in Idaho and described the habitat there as one of the grizzly bear's last strongholds. He indicated that the bears were "fairly plentiful" in extreme northern Idaho but were confined to the Bitterroot, Clearwater, Lolo, and Salmon River Mountains in the Bitterroot Range. Moore (1984), a trapper and retired Forest Service employee, reported encounters with grizzlies in 1930 and 1931. He also described earlier reports of grizzlies being trapped and shot by others. According to Moore, the last documented sign of grizzly bears was recorded in the mid-1940's by Parsell, a Forest Service Ranger on the Selway. Melquist (1985) analyzed 88 reports of grizzly bears, including the reported killing of a grizzly on the upper Lochsa River in 1956 by District Ranger Puckett.

Historical information indicates the grizzly bear once occupied the SBGBE; one can infer from these reports that the habitat must have been sufficient in quality and quantity to support a viable grizzly population. What, then, caused grizzlies to virtually disappear from the SBGBE?

Fire

Fire, which has burned the SBGBE area for thousands of years, undoubtedly played a major role in shaping and creating quality bear habitat. In his field studies, Habeck (1972) could not find any area "that did not reveal direct evidence of past fire disturbance...even in the oldest forest communities encountered, and in communities at all elevations." Frequent fire has even been documented in the high-elevation spruce/fir zone at, and above, timberline (Habeck and Mutch 1973). Leiberg (1900) reported that large amounts of the Selway-Bitterroot Wilderness burned between 1719 and 1898. Habeck (1972) reported large wildfires in 1910, 1919, and 1934 that burned millions of acres.

In the 1930's, the Forest Service initiated an extremely effective fire prevention and control program that has significantly reduced fire occurrence. From 1934 to 1970 only 12,000 acres burned. Habeck (1972:29) stated that "the extent of fire reduction has been significantly high for a sufficient number of years so that one must assume that there has been or is an environmental impact imposed on the SBW forest ecosystems that requires clear recognition and description."

Fisheries

Another important resource of the SBGBE was the chinook salmon (*Oncorhynchus tshawytscha*) fishery. Wright (1909) considered the grizzlies of the Bitterroot area to be skilled at fishing and noted that the bears appeared to depend upon these fisheries for at least 2 months of the year. Before 1927, there was a significant run of spawning chinook in the SBGBE. In 1927, however, Inland Power and Light Company constructed a dam across the Clearwater River at Lewiston, ID, to generate electricity and build a lake that could be used to boom logs for the new Potlatch mill. Fish ladders were included in the construction but failed to function properly, so the 35-ft-high obstruction virtually eliminated the upstream chinook fishery.

Biologists have suggested that the loss of the anadromous fishery was central to the disappearance of grizzlies from the SBGBE; however, because the grizzly bear is very adaptable and inhabits areas without a major anadromous fishery, the impact may have been only short term. Grizzlies have survived in the nearby Cabinet-Yaak and Selkirk ecosystems without anadromous fish runs. Undoubtedly, however, the loss of this important food source did come at a time when many other pressures were being imposed on the grizzly bear. Collectively, these changes could have had a significant influence.

Grazing

The large fires encouraged the growth of vegetation conducive to grazing of domestic livestock, and homesteaders from the Selway, Clearwater, and Bitterroot valleys were quick to take advantage of this newly created resource. Space (1979) reports that sheep grazing steadily increased in the early 1900's and peaked around 1935 when 35,000 sheep were found in the area. Grizzly bears presumably foraged on preferred vegetation of burned areas and at times preyed on livestock. Stockmen reportedly feared the grizzly and killed every bear they encountered. Grizzlies were also killed and trapped to protect big game. Moore (1984) reported that trappers near the turn of the century killed 25 to 40 grizzlies annually in the Bitterroot Mountains.

Most herbaceous grizzly foods are also listed as forage plants for domestic livestock (U.S. Department of Agriculture, Forest Service 1969). Livestock using grizzly habitat prefer foods important to grizzlies (Mealey and others 1977; Schallenberger 1976). Mealey (1977) reported that domestic livestock graze important wet areas much more efficiently and occur in greater densities than grizzlies do. The subsequent increased foraging and trampling of vegetation can reduce or eliminate the use of these areas by grizzlies. This direct competition for high-quality forage areas and the killing of bears that interfere with grazing activities thus significantly affect grizzly habitat.

CURRENT SITUATION

Observations

Jonkel (1981:2) has recognized the potential for grizzly bear recovery in the SBGBE. After reviewing past reports, he concluded that "there seems little doubt that the Bitterroot Range and the Selway-Bitterroot area contains a small number of grizzlies." During 1984, Melquist (1985) conducted a preliminary survey in the Clearwater National Forest that failed to provide actual evidence of grizzly bears, but his analysis of 88 reported grizzly bear observations from the same area for the period 1900 to 1984 indicated that circumstantial evidence was enough to conclude that a few grizzlies probably occupy the area, at least as temporary residents.

Eight of the 88 reported observations were classified as kills; the most recent was in 1978. Although two of the eight were classified as confirmed kills, one in 1909 and the other in 1956, further investigations suggest that there may be no material evidence to substantiate these reported kills; therefore, confirmation remains questionable.

Ten of the 88 reports were of sows accompanied by cubs. Six of these reported observations were in the 1970's and three during the 1980's. Following analysis of these reports, Melquist concluded that one or more reproductive females may reside in the area, but he pointed out that the data were neither conclusive nor convincing. Additional reports from the Clearwater National Forest are being evaluated, and survey efforts are now extending into the Nezperce National Forest and SBGBE.

Fire

Fire management policies for the Selway-Bitterroot Wilderness changed significantly in 1979. Approximately 1.24 million acres are now managed under a fire plan that will allow lightning fires to play a more natural role in shaping and perpetuating the wilderness ecosystem (Forest Service 1979). Additional policy changes as recent as January 1985 allow the use of both natural wildfire and prescribed fire in wilderness under certain circumstances (Forest Service 1985). These changes will undoubtedly benefit grizzly bear habitat within the SBGBE, as most of the preferred forage species west of the Continental Divide are created and rehabilitated by wildfires (Mealey 1977). Mealey further states that burns in this region are probably the single most important grizzly habitat component. Since 1979, approximately 30,000 acres have been burned under management prescription. At this rate, a significant portion of the SBGBE could become rehabilitated grizzly bear habitat in the foreseeable future.

Habitat

To properly address the recovery plan's second objective of determining the space and habitat necessary to support a viable grizzly population, one must intensively evaluate and map habitat components. Scaggs (1979) suggests that an area could be evaluated for its suitability as grizzly bear habitat even when bears are absent. His research in the SBGBE was to describe and evaluate the vegetation of a 40-mi^2 area and determine its suitability as grizzly bear habitat. Scaggs stated that "the area rated very good as potential grizzly bear habitat." He further suggested that the subalpine zone, comprising 45 percent of the study area rated as "superior" grizzly habitat. The remaining 55 percent was classified as a temperate zone which rated as "good." He also indicated that the study area was representative of habitat found throughout the Bitterroot Mountains.

If Scaggs is correct, a substantial amount of the SBGBE may be suitable grizzly bear habitat. Further habitat analyses are clearly necessary, however. Funding to continue this type of habitat evaluation for SBGBE has recently become available. For fiscal year 1985, $20,000 (4 percent) of the regional grizzly bear budget has been allocated to the SBGBE. During the 1985 field season, researchers will try to determine whether grizzly bears are present by collecting and evaluating all grizzly reports. To enhance the credibility of "probable" and "highly probable" reports (Melquist 1985), they will conduct some aerial surveys. Because of limited funding, however, only a cursory evaluation of grizzly habitat components can be made at this time.

Fisheries

Hydroelectric development eliminated 50 percent of the chinook fishery habitat. The remaining habitat available for production is at approximately 80 percent of its potential because of impacts associated with logging, road building, and mineral exploration. Also, the present chinook population is only at 15 percent of potential. Continued impacts on the chinook fishery are anticipated; however, this factor alone would probably not preclude the SBGBE from supporting a viable population of grizzly bears. Fishery recovery would certainly enhance bear habitat.

Grazing

Livestock grazing in the SBGBE is negligible, and most grazing is by horses used for guide and outfitting services during hunting season. Only a small amount of cattle and sheep grazing occurs in the area. The trend is to phase out or relocate the remote cattle allotments because they are costly to operate and the range is transitory. Livestock grazing is therefore not anticipated to significantly affect recovery of the grizzly bear population.

Recreation

The elk population has dramatically increased in the SBGBE because of the effects on habitat of large wildfires in the early 1900's and the establishment of refuges in the portions of the area. Refuge designation was discontinued once populations could sustain an annual hunting harvest. Hunter recreation use has risen in conjunction with the elk population. A significant increase in nonhunting recreation such as fishing and hiking has also occurred. All types of recreational use are projected to increase. Compared to the Yellowstone or Glacier ecosystems recreational use in the SBGBE is very low. This

relatively low level of recreational use would minimize potential human/bear conflicts.

Public Information/Education

The only effort to inform the public about grizzly bear recovery efforts in the SBGBE has been a poster that was distributed in 1984 to increase accuracy of reports on the Clearwater National Forest (fig. 2). The poster depicts key characteristics for identifying grizzlies and gray wolves (Canis lupus irremotus) and requests that observations be reported to authorities. Informational programs to describe grizzly bear recovery efforts and ways to avoid potential human-bear conflicts will become a key factor in the SBGBE.

Figure 2.--Posters used to increase accuracy in identification of grizzlies and gray wolves.

CONCLUSIONS AND RECOMMENDATIONS

The information presented in this report suggests that a large area of land in central Idaho was once occupied by grizzly bears. A combination of factors has probably been responsible for the virtual elimination of the bear from this area, most of which have significantly changed, leaving this area of potential habitat available but virtually unoccupied. The available habitat is much larger than that suggested in the Grizzly Bear Recovery Plan. Compared to the five other identified ecosystems, central Idaho may offer the largest contiguous area of land in which to recover a viable population of grizzlies without escalating major conflicts. Further studies are clearly needed to better evaluate the situation. An adequate analysis will also require a significant increase in priority and funding for the SBGBE. Circumstantial evidence provided by 88 reports evaluated by Melquist (1985) suggests that an area of land along the Idaho-Montana border within the Clearwater National Forest would serve as potential habitat or at least a travel corridor linking the SBGBE with the Cabinet-Yaak ecosystem.

The legal mandate to recover the grizzly bear is clearly established; however, the role of each ecosystem in achieving this goal is not clear. We suggest that central Idaho may be crucial to the recovery effort; unfortunately the area is receiving little attention.

RECOMMENDATIONS

We make the following management recommendations for the SBGBE:

1. Continue to gather, evaluate, and document all potential grizzly bear reports.

2. Increase public awareness and information about grizzly bear recovery efforts.

3. Develop a plan to evaluate habitat use and movements of grizzlies known to be in the SBGBE.

4. Adequately evaluate and map grizzly bear habitat components.

5. Based on the above information, define and delineate a recovery area in central Idaho.

REFERENCES

Arno, Stephen F. Ecology of alpine larch (Larix Lyallii Parl.) in the Pacific Northwest. Missoula, MT: University of Montana; 1970. 264 p. Ph.D. thesis.

Burroughs, Raymond D. The natural history of the Lewis and Clark expedition. East Lansing, MI: Michigan State University Press; 1961: 57-68.

Habeck, James R. Fire ecology investigations in the Selway-Bitterroot Wilderness; historical considerations and current observations. Publication No. R1-72-001. University of Montana and U.S. Department of Agriculture, Forest Service; 1972. 128 p.

Habeck, James R.; Mutch, Robert W. Fire-dependent forests in the Northern Rocky Mountains. Quaternary Research. 3(3): 408-424; 1973.

Jonkel, Charles. The Selway-Bitterroot wilderness and the Bitterroot Range grizzly bears. BGP Special Report No. 52. Missoula, MT: University of Montana: 1981, 5 p.

Lackschewitz, K. H. Alpine and timberline flora in the Bitterroot Mountains; Proceedings, Missoula, MT: Montana Academy of Science; 1970. 30 p.

Layser, Earle F.; Weaver, John L.; Carrier Dean. What's to be done with the grizzly? Idaho Wildlife. 1 (6): 3-10; 1979.

Leiberg, J. B. The Bitterroot forest reserve;

Part V: Forest Reserves. 20th Annual Report. Washington, DC: U.S. Department of the Interior, Geological Survey; 1900: 317-410.

Lindgren, William. A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho. Prof. Paper No. 27. Washington, DC: U.S. Department of the Interior, Geological Survey; 1904. 22 p.

Mealey, Stephen; Jonkel, Charles; Demarchi, Ray. Habitat criteria for grizzly bear management. In: Proceedings, 13th international congress of wildlife biologists. Washington, DC: Wildlife Management Institute; 1977. 8 p.

Mealey, Stephen P. Method for determining grizzly bear habitat quality and estimating consequences of impacts on grizzly habitat quality. 1977. Unpublished draft paper on file at: U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT.

Melquist, Wayne E. A preliminary survey to determine the status of grizzly bears in the Clearwater National Forest of Idaho. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station; 1985. 50 p.

Merriam, C. H. Distribution of grizzly bear in the U.S. Outdoor Life; 1922 December: 405-406 (Cited in Layser and others, 1979.)

Moore, William R. Last of the bitterroot grizzly. Montana Magazine. 1984 November-December: 8-12.

Scaggs, Gordon B. Vegetation description of potential grizzly bear habitat in the Selway-Bitterroot wilderness area, Montana and Idaho. Missoula, MT: University of Montana; 1979. 148 p. M.S. thesis.

Schallenberger, A. Grizzly bear habitat survey, Badger Creek-South Fork Two Medicine Management Unit, Lewis and Clark National Forest. 1976. Unpublished Report on file at U.S. Department of Agriculture, Forest Service, Northern Region; Missoula, MT.

Smith, B. L. Ecology of Rocky Mountain goats in the Bitterroot Mountains. Missoula, MT: University of Montana; 1976. 203 p. M.S. thesis.

Space, Ralph. The Clearwater story. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region; -79-03. 1979. 234 p.

U.S. Department of Agriculture, Forest Service. Forest Service Manual, Chapter 2320. Washington, DC. 1985. 3 p.

U.S. Department of Agriculture, Forest Service. Range environmental analysis handbook (FSM 2209.11). Missoula, MT: Northern Region; 1969.

U.S. Department of the Interior, Fish and Wildlife Service. Grizzly bear recovery plan. Washington, DC; 1982, 195 p. In cooperation with: Recovery Plan Leader, Don L. Brown, Montana Department Fish, Wildlife, and Parks under cooperative agreement No. 14-16-0006-80-923.

Wright, William H. The grizzly bear. Lincoln, NE: University of Nebraska Press; 1909 (Reprinted 1977). 274 p.

USE-AVAILABILITY ANALYSIS AND TIMBER SELECTION BY GRIZZLY BEARS

B. N. McLellan

ABSTRACT: Use-availability analysis methods used to determine habitat selection will rarely find common habitats selected for even if they are often used by an individual or population. Several of these methods are briefly reviewed and a shortcoming, common to all, is identified. This shortcoming is the animal's "knowledge." It is postulated that if (1) an individual knows the location of habitats within its home range, (2) there is relatively little cost in moving between habitats, and (3) resources in a habitat are not depleted with the study's duration, then what the animal uses is what it selects. Based on this concept, the degree at which grizzly bears select the habitat component "timber" greatly increases when compared to conventional analyses. It is recommended that land management agencies recognize the potential importance of the timber component when mapping and managing grizzly bear habitat.

INTRODUCTION

The number of methodology papers written on a topic may be a function of its importance and the difficulties encountered when attempting to provide a quantitative analysis of it. Resource selection is both important and difficult to quantify. As expected, the literature describes many different methodologies. In this paper, I will briefly review some of the methods as they relate to grizzly bear habitat component (GBHC) selection and will focus on the GBHC "timber" for two reasons: First, because it is a common component in most study areas; it highlights the problem with many proposed methods of measuring resource selection. Second, in some areas the timber component is not being mapped as grizzly bear habitat.

PROBLEMS WITH EVALUATING RESOURCE SELECTION

One would think that, if a particular resource or habitat was frequently used by an individual or a population, it would be classified as "selected for." Unfortunately, the use-availability analyses used by many ecologists may find a highly used resource "used less than expected" or even "avoided." If this conclusion was uncommon, it would cause less concern; however, it is a conclusion whenever one resource is deemed by the researcher to be much more available to the animal than others.

The methods based on the forage ratio concept, although usually used for food selection, have this problem. In its simplest form, the forage ratio or preference index is the proportion of a particular resource (u) that is used, divided by the proportion that is found in the animal's environment (a) (Hess and Rainwater 1939; Hess and Swartz 1940; Williams and Marshall 1938):

$$PI = \frac{u}{a} \qquad (1)$$

If a resource is to be classified as selected for (PI > 1.0) and its proportion in the environment is large, say 50 percent, then 'u', the proportion of the resource in the use category, must be greater than 50 percent. Some authors have categorized these preference indexes or ratios as high (>1.5), medium (0.75 to 1.5), or low (<0.75) (Ault and Stormer 1983; Healy 1971). With these categories, a resource could not be classified as high preference even if it was the only resource used (u = 100 percent), unless 'a' was less than 66.7 percent. On the other hand, a resource that was rare in the environment, say 'a' = 3 percent, would have a high PI if 'u' = 5 percent.

People interested largely in a predator's prey selection have created more elegant modifications to this theme. Ivlev's "electivity index" (Ivlev 1961) was one of the first. This index is calculated with equation 2, wherein 'u' and 'a' are defined as in equation 1.

$$E = \frac{u - a}{u + a} \qquad (2)$$

Again, if 'a' is large, 'u' must also be large if the resource is not to become selected against. Jacobs (1974) recognized the problem with different abundances and modified the preference index and the index of electivity to:

$$PI = \frac{u(1-a)}{a(1-u)} \qquad (3)$$

$$E = \frac{u-a}{u+a-2ua} \qquad (4)$$

The problem with unequal availabilities, however, still occurs.

Chesson (1978) suggests a prey selection index that calculates the proportion of the diet that would consist of a particular food type if all foods were equally abundant in the environment.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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Her method likely provides a realistic estimate of prey selection in some cases, but problems arise if the index is used for habitat selection in areas of unequal habitat component availability.

The statistical method of determining resource selection as proposed by Neu and others (1974) has been commonly used to determine habitat selection by grizzly bears (Servheen 1983; Zager 1980). This method rarely finds a common resource selected for because the resource must not only be used more than its availability but significantly more. Thus, a habitat component that covers half an animal's home range (a = 0.5) may have to be used over 75 percent of the time to be classified as selected for.

The method proposed by Johnson (1980) is based on the difference between ranks of use and availability. Again, if one resource is most common (availability rank = 1) and is also most often utilized (use rank = 1), it may not be classified as highly preferred because its preference ratings will depend on the rank differences of all other resources.

The basic underlying assumption involved with statistical and index methods, which is likely true in most cases, is that in the absence of active selection, habitats or foods would be used in proportion to their availability (Chesson 1978; Pietz and Tester 1982; Talent and others 1982). If the two frequency distributions--one for resource use and the other for what the researcher calls available--differ, resource selection is indicated. Once it is agreed that animals actively "select" resources from a wide array of opportunities, we should think of how the animal does this selecting.

First, if selection occurs, an animal must be able to detect the difference between resources and determine which provide benefits and which do not. Second, to select efficiently, an animal must not only be capable of learning which resources are beneficial but also where to find them within its home range. It is believed that a major reason for an animal's establishing a home range is that it can exploit a familiar area much more efficiently than it can an unfamiliar area. How well an individual animal learns and remembers its range, choice feeding sites, bedding sites, travel routes, favored areas of potential mate, and so on, remains unknown for most, if not all, species. Some learning ability by mammal species is certain, however, and a substantial ability by some species--at least in individuals living in a predictable environment--is expected.

This assumption is based in part upon personal experience gained from radio-tracking grizzly bears. This experience leads me to believe that an animal capable of knowing its range likely moves from a known, selected feeding or bedding site over selected travel routes to other known selected sites. If this is the case, the animal will always be at a site that it has selected at that particular time for a particular reason. Therefore, the relative resource-use distribution, which a researcher obtains from sampling an animal's locations, is the same as resource selection. This applies when (1) the animal knows the location of all resources (that is, habitat components); (2) the energy costs of moving between resources are minimal; (3) the resource is not depleted during the study period, thus forcing the animal to use "second best."

An analogy may support my reasoning. Suppose a person attends a social gathering where a 500-kg steer and a 100-kg pig are being roasted on a spit. He takes a slice of beef and a slice of pork of equal proportions. Using the use-availability analysis he would have selected pork over beef when in reality he selected them equally.

I believe, for the most part, that these assumptions hold true for grizzly bears selecting at the habitat component level if they have an established home range. The selection of foods is a different matter because it is unlikely that omniscience prevails at this level of selection, although within a feeding site or a "sensing radius" the assumptions may prevail. A need for studying resource selection at each level, as mentioned by Johnson (1980), is required.

SELECTION OF TIMBER

If we agree that at the habitat component level of selection, use is equal to selection, then the apparent selection for the component "timber" changes. Servheen (1983) stratified his study area into 19 habitat components. From his figure 4, it appears that timber constituted about 15 percent of his study area and timber shrubfield about 27 percent. Using the method of Neu and others (1974), he found both of these components to be used less than expected; however, they were the fourth and second most often used of the 19 components (10 and 20 percent of locations). Why were the bears so often found in these areas if they were not preferred? They had many options.

Zager (1980) found bears avoided timber in spring and summer-fall. His figure 11 shows timber to be the fifth most commonly used of his 11 components in both seasons, with about 10 percent of the locations occurring in timber during each season. It appears that timber is used much less in the South Fork of the Flathead than in the Mission Mountains.

In my study area, the North Fork of the Flathead, grizzly bears appear to have at least four recognizable seasons, excluding winter. The first season, early spring, is from den emergence until the vegetation begins to green. This season can be about 5 weeks long for some bears but nonexistent for others. The second season, spring, is from green-up to when berries become ripe and is about 9 weeks. The third season, summer, is when berries are ripe and available. This season is usually about 8 weeks. The last season, autumn, is from when the huckleberries have largely dropped until the bears den. This season also varies in length between individuals and years but is about 5 weeks long.

Table 1.--Seasonal use of the component timber

Season	Number of bears	Bear seasons	Radio locations	Percent in timber[1]	Rank of timber
Early spring	8	16	154	41.4	1
Spring	26	50	1,471	19.9	2
Summer	22	44	1,110	8.6	5
Autumn	21	42	614	38.2	1

[1]Mean across individual bears.

Table 1 compares the use of timber during each season by the 26 bears for which adequate information was obtained. Timber was the most frequently used habitat component during early spring and autumn and second most commonly used during spring (riparian was first, and this component is often timbered as well). Only during the summer (berry season) was timber rarely used.

Determining selection of bedding and feeding sites within a component is difficult and time consuming. Consequently, only the most highly used components during the longest seasons have been investigated. The very broad and heterogeneous nature of the timber component makes estimating the selection process within it difficult. I will, however, mention some important features of this component.

During early spring, timber is the most commonly used component. Both major early spring foods, sweet vetch roots (Hedysarum sulphurescens) and large mammals, occur in this component. Unfortunately, the patchy distribution of sweet vetch within timber and many other components creates an enormous mapping problem. Grizzly bear killing and carrion-feeding sites most often occur in timber because of the concentration of winter-weakened ungulates. Timber is often used for travel and bedding during early spring. During the earliest part of this season (first 3 weeks of April), bears have been tracked through timber on the snow for many kilometers, and feeding and defecating appears to be rare.

When green-up begins (usually in mid-May), the use of timber is reduced. Foraging on grasses and other plants in wet seeps occurs in timber, as does a small amount of digging for sweet vetch. During this season timber is also used for travel and bedding. In the summer berry season, timber is rarely used.

During the autumn, timber is once again the most commonly used component. As in early spring, sweet vetch roots and ungulates--largely hunter kills, gut piles, and cripple loss--are the major foods. Fruits of several shrubs are also important. Again, it would be difficult to map only highly used timbered sites without detailed telemetry work.

SUMMARY AND RECOMMENDATIONS

Johnson (1980) mentions an imaginary situation where an animal is foraging in a site containing 90 percent of a particular food item, yet only 50 percent of its food consumption consists of that item. Conventional use-availability analysis would find that food avoided, when in reality, the animal may have chosen that feeding site because the food item was so abundant. At a higher level of resource selection, a grizzly bear may not use timber in proportion to its availability within its home range but may have chosen the home range (or be still alive in the home range) because of the abundance of timber.

How important is timber? With grizzly bears it is difficult enough to determine habitat selection. Determining habitat importance or need would require large-scale experimentation and population monitoring.

At this time I recommend that land use agencies that do not map timber as grizzly bear habitat at least mention its importance, particularly when it is adjacent to other selected habitats.

REFERENCES

Ault, Stacey C.; Stormer, Fred A. Seasonal food selection by scaled quail in northwest Texas. J. Wildl. Manage. 47(1): 222-228; 1983.

Chesson, Jean. Measuring preference in selective predation. Ecology. 59: 211-215; 1978.

Healy, William M. Forage preferences of tame deer in a northwest Pennsylvania clear-cutting. J. Wildl. Manage. 34: 717-723; 1971.

Hess, A. D.; Rainwater, J. H. A method for measuring the food preference of trout. Copeia. 3: 154-157; 1939.

Hess, A. D.; Swartz, Albert. The forage ratio and its use in determining the food grade of streams. Trans. N. Am. Wildl. Conf. 5: 162-164; 1940.

Ivlev, V. S. Experimental ecology of the feeding of fishes. New Haven, CT: Yale University Press; 1961. 302 p.

Jacobs, Jurgen. Quantitative measurement of food selection. Oecologia (Berlin). 14: 413-417; 1974.

Johnson, Douglas H. The comparison of usage and availability measurements for evaluating resource preference. Ecology. 61(1): 65-71; 1980.

Neu, Clyde W.; Byers, C. Randall; Peek, James M. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38(3): 541-545; 1974.

Pietz, Pamela J.; Tester, John R. Habitat selection by sympatric spruce and ruffed grouse in north central Minnesota. J. Wildl. Manage. 46(2): 391-403; 1982.

Servheen, Christopher. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. J. Wildl. Manage. 47: 1026-1035; 1983.

Talent, Larry G.; Krapu, Gary L.; Jarvis, Robert L. Habitat use by mallard broods in south central North Dakota. J. Wildl. Manage. 46: 629-635; 1982.

Williams, C. S.; Marshall, W. H. Duck nesting studies, Bear River Migratory Bird Refuge, Utah, 1937. J. Wildl. Manage. 2: 29-48; 1938.

Zager, Peter Edward. The influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Missoula, MT: University of Montana; 1980. Ph.D. dissertation. 131 p.

GRIZZLY BEAR HABITAT SELECTION AND MOVEMENTS IN THE CABINET MOUNTAINS OF MONTANA

Wayne F. Kasworm

ABSTRACT: The Cabinet-Yaak Grizzly Bear Ecosystem (CYGBE) occupies about 4,860 km^2 in northwestern Montana and northern Idaho. Of this area, 90 percent is administered by the USDA Forest Service. Primary resource development demands in the CYGBE consist of mineral exploration and extraction, timber harvest, and recreation. The Cabinet Mountains Grizzly Bear Study began in 1983 through funding provided by the U.S. Borax and Chemical Corporation, the U.S. Fish and Wildlife Service, and the Montana Department of Fish, Wildlife, and Parks. Two grizzly bears have been instrumented and monitored. Telemetry from these two animals is the main source of grizzly bear habitat use data in the CYGBE. Comparisons of study results in the CYGBE are made, including management recommendations.

This information is available in:

Montana Department of Fish, Wildlife, and Parks. Cabinet Mountains grizzly bear study. 1984 annual progress report. Libby, MT; 1984.

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GRIZZLY BEAR HABITAT COMPONENTS OF THE ROCKY MOUNTAIN EAST FRONT

Keith Aune and Tom Stivers

ABSTRACT: Seventeen grizzly bear habitat components are defined for the Rocky Mountain East Front. Each is characterized by unique vegetation cover types and physical attributes. Some of these components are often closely associated with each other and are defined as component associations. Vegetation structure and composition was determined from data collected at bear activity sites. Activities of bears within each component are described. Season of use and a procedure for determining important values for each component are discussed.

This information is available in:

Aune, K; Stivers, T.; Madel, M. Rocky Mountain Front grizzly bear monitoring and investigations. Helena MT: Montana Department of Fish, Wildlife, and Parks; 1984. 239 p.

Aune, K. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife, and Parks; 1985. 138 p.

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Session V—Habitat Improvement and Coordination

Chaired by:

Dan Hinckley, Wildlife Management Biologist, Bureau of Land Management, Billings, MT

Lorin Hicks, Wildlife Biologist, Plum Creek Timber Co., Seattle, WA

MANAGEMENT OF WHITEBARK PINE AS POTENTIAL GRIZZLY BEAR HABITAT

Douglas E. Eggers

ABSTRACT: Whitebark pine (Pinus albicaulis) is becoming a focal point in forest management because of its potential role in the recovery of grizzly bears. To make well-informed decisions concerning land use choices on lands which now support stands of whitebark pine, it is necessary to understand some of the species characteristics. The most important aspect of stand perpetuation is regeneration capacity. Natural regeneration has been found to be sporadic, at best, with consistent losses from birds and mammals. The seed that does survive predation has been shown to have low germination. The difficulty with poor germination also extends to seeds sown in nurseries; however, artificial regeneration with containerized stock appears to be the only presently practical, consistent method of regenerating whitebark pine.

INTRODUCTION

Whitebark pine (Pinus albicaulis) is found most often at higher elevations within its two major distributions in western North America. One population extends from about lat. 55° N. in western British Columbia to about lat. 36° N. in the Sierra Nevada. The eastern population also extends from about lat. 55° N. in Alberta and eastern British Columbia to about lat. 41° N. in northeastern Nevada. The eastern limit is the Wind River mountains in northwestern Wyoming.

The principal uses for whitebark pine are ornamental, cover and food sources for various mammals and birds, watershed maintenance, and forest products such as lumber, posts, poles, and firewood. The wood from whitebark pine is classified as "soft pine," with a specific gravity just slightly less than lodgepole pine (Pinus contorta Dougl. ex Loud.). The strength properties of the wood are similar to western white pine (Pinus monticola Dougl. ex D. Don). The species is marketed along with lodgepole pine in Canada and in Rocky Mountain portions of the United States.

Craighead and others (1982) have reported that the seeds of whitebark pine are a preferred food for grizzly bears. The importance in a particular year's diet depends on the size of the seed crop; however, when ample seed is available, bears will feed on it in the spring and fall seasons.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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ECOLOGY AND STAND REGENERATION

Tree and Stand Characteristics

Whitebark pine is a five-needled pine of the subgenus Strobus. There are two distinct morphological forms. The form that many people associate with timberline vegetation grows in clumps with two or more stems. This form occurs on the Bridger-Teton National Forest in northwest Wyoming on high ridges exposed to strong winds. These trees will sometimes have a flagged, krummholz appearance, with most of the stout, flexible limbs on the leeward side of the trunk. The trees are rarely over 30 feet tall. The other prevalent--if less well-recognized--growth form on the Bridger-Teton occurs in mixed or pure stands. It has a single, upright, straight stem with good form-class. These trees are of the same canopy level as the associated trees (most commonly lodgepole pine) and of similar quality. A number of pure to nearly pure whitebark pine stands on the Bridger-Teton National Forest average 75 to 90 feet tall and 12 to 14 inches d.b.h.

The bark of whitebark pine is relatively thin (rarely over 1/2 inch thick), so its yield of wood for a given diameter is comparable to that of associated species. This characteristic also makes it vulnerable to damage by fire.

Whitebark pine needles are medium to dark green with a light-colored stomatal line on the back surfaces. The stout, orange branchlets retain the 1-1/2 to 2-1/2 inch-long needles for as long as 7 or 8 years before shedding them.

Whitebark pine is highly intolerant of shade except during early stages of development. It is somewhat more shade tolerant during all stages of development under moister conditions.

Little has been published on genetic variation in whitebark pine; however, considering the range of the species, it would be safe to assume that growing period, rate of growth, and frost tolerance vary by seed source.

Associated Vegetation

In the over 50 forest habitat types identified in the eastern Idaho-western Wyoming area, whitebark pine was found in 36. On the Bridger-Teton National Forest, whitebark pine occurs with lodgepole pine, limber pine (Pinus flexilis James), Engelmann spruce (Picea engelmanii Parry ex Engelm.), subalpine fir (Abies lasiocarpa (Hook.) Nutt.), Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), and aspen (Populus spp.). The single-stemmed growth form is most commonly associated with lodgepole pine. Common shrub and herbaceous associates are listed in "Forest Habitat Types of Eastern Idaho-Western Wyoming".

Environmental Factors

Soils and topography.--In many areas whitebark pine distribution appears to be influenced strongly by acidic, rather than calcareous, substrates. The other five-needled pine which grows in this area, limber pine, has an apparent affinity for soils of limestone (calcareous) origin. In areas where whitebark pine appears to be climax, the soils are relatively coarse.

Topographic position affects the soil depth and severity of growing conditions and, subsequently, tree size and form. For example, whitebark pine growing on cold, windswept, southeast to northwest exposures will be short and scrubby. More protected locations produce relatively tall, symmetrical trees.

Soil moisture requirements of whitebark pine are moderate.

Insect pests.--The most important insect pest for whitebark pine is the mountain pine beetle (*Dendroctonus ponderosae*, Hopkins). The factors affecting mountain pine beetle attack on whitebark pine have not been studied thoroughly, but in northwestern Wyoming most attacks occur after a build up of beetle population in lodgepole pine at lower elevations.

In an endemic situation mountain pine beetles prefer the species of tree in which larvae mature. In studies done by Amman (1982), larvae raised in whitebark pine were more successful than those reared from lodgepole pine, perhaps because whitebark pine is a better nutritional source. The host preference mechanism would thus indicate that the higher the proportion of whitebark pine in a stand, the greater amount of tree killing. The epidemic situation, however, differs in that any acceptable host will be attacked and in some cases any conifer.

Numerous other insects do not cause widespread losses but may become important periodically. These insects include moths such as the lodgepole needletier (*Argyrotaenia tabulana*), bark beetles such as *Pityogenes knechtel* and *Pityogenes carinulatus*, and various species of pine engraver (*Ips* spp.).

Pathogens.--

1. Dwarf Mistletoe.--Dwarf mistletoe is a parasitic flowering plant which increases mortality, decreases seed production, and reduces wood production and quality. Whitebark pine is an occasional host for lodgepole pine dwarf mistletoe (*Arceuthobium americanium*) and a secondary host for limber pine dwarf mistletoe (*Arceuthobium cyanocarpum*). The limber pine dwarf mistletoe has been identified from southern Montana to Utah and Colorado; therefore, it is reasonable to assume that it exists in northwest Wyoming also.

2. Root diseases.--The most prevalent root disease is shoestring root rot (*Armillariella mellea*), which is associated with physiological stress, usually drought. An example of a drought situation would be steep south-facing slopes with shallow soils. When shoestring root rot results in mortality it shows up in the spring after snowmelt. Two other important root diseases are brown cubical butt rot, caused by *Polyporus schweinitzii*, and spongy rot, caused by *Polyporus subacida*.

3. Foliage diseases.--Various needle diseases are common to all pine, but the most important are *Herpotrichia nigra* and *Neopeccia coulteri*, which are snow molds. These snow molds destroy foliage when needles remain under snow for long periods.

4. Stem diseases.--A number of stem diseases affect whitebark pine; by far the most important is white pine blister rust (*Cronartium ribicola*). Blister rust causes spindle-shaped cankers on branches and the main stem. The result is usually death in sapling and pole-sized trees and top-kill in mature trees. The attacks of this disease are at times severe enough to kill most of the host trees in a drainage. This disease has an alternate host, *Ribes* spp. Several species of *Ribes* occur on the Bridger-Teton in habitat types which include whitebark pine. Some evidence indicates that white pine blister rust can also use *Castilleja* spp. as an alternate host. This is of importance on the Bridger-Teton, where *Castilleja* spp. is widespread. Hoff's (1980) experiments showed that whitebark pine is highly susceptible to white pine blister rust even on trees with disease-resistant parents.

Fire.--More than any other factor, fire has shaped the forests on the Bridger-Teton. The thin bark of whitebark pine makes it even more vulnerable to damage by fire than some other species. Those whitebark pine stands located on alpine areas, such as the heads of drainages, have long regeneration periods, as evidenced by historic photos taken by Gruell (1980). Natural regeneration periods of 50 years or longer in these areas are important considerations for the perpetuation of whitebark pine.

Stand Regeneration

Flowering and Fruiting.--In pines, male and female strobili are found on the same tree. Female strobili (seed cones) are most often borne in the upper crown. Male strobili (pollen cones) occur most frequently on older branches in the lower crown. This characteristic prevents much self-fertilization. A three-year interval is required from the time the male and female strobili are initiated until the time the seed matures. Cones are sessile, that is, attached at the base, not on a stalk, and occur in clusters of two to five around the end of the branches where they are not covered by needles. Pollen is usually shed in late June and early July of the second growing season. The exact time of pollination varies with latitude, site, and elevation.

As with other pine species, fertilization does not take place until 12 to 14 months after pollination. This long period increases exposure to insects and environmental changes that can reduce cone production. After fertilization, cones and seeds mature in late August and early September. Cone maturity is indicated by a change from a dark purplish brown to a dull purple or brown. The ripening cones may have beads of oleoresin issuing from resin ducts on the rounded portion of the cone scales.

Seed Production.--The literature indicates that cone bearing can begin at 20 to 30 years and collectible crops will occur at 3 to 5 year intervals. Cone production on individual trees varies greatly, primarily because of spacing. It has been consistently shown that well-spaced trees produce more seed than those growing closely together. The effect of spacing is more pronounced in intolerent species such as whitebark pine. Spacing control can produce trees with a higher proportion of fully exposed crown, which is more likely to bear flowers (Daniel 1979). This application of density management (thinning) is most valuable in pure, open-grown whitebark pine stands. In closed-canopy mixed species stands the opportunity to increase seed production is significantly less, making selection of individual trees with full crowns more important.

Seed Dissemination.--Whitebark pine cones have been described as indehiscent (remaining closed at maturity), but personal observation on the Bridger-Teton National Forest has not shown that to be the case. My observations and others' (Hutchins and Lanner 1982; Tomback 1981) demonstrate that as the cones ripen, the cones scales separate slightly to partially expose the seed. The seed, however, is held firmly in place until the cone scales come loose from the cone.

The seeds of whitebark pine are relatively heavy (2,200 to 3,000 seeds per pound). In comparison, lodgepole pine averages about 94,000 seeds per pound. The heavy, wingless seed, coupled with the cone characteristic of holding the seed until the scales come off, make wind an insignificant factor in seed dispersal. Natural seedfall from disintegrating cones could therefore only be expected to be effective from 0 to 15 feet from the tree.

The major dispersal agents are birds and mammals. Observations show that the two most effective carriers are red squirrels and Clark's nutcrackers (Hutchin and Lanner 1982).

Seed Losses.--The pine species in this area produce seeds which are important food sources for various species of birds and mammals. Hutchins and Lanner (1982) observed the following vertebrates foraging on whitebark pine in the Squaw Basin area of the Bridger-Teton National Forest: Clark's nutcracker (*Nucifraga columbiana*), Steller's jay (*Cyanocitta stelleri*), raven (*Corvus Corax*), pine grosbeak (*Pinicola enucleator*), mountain chickadee (*Parus gambeli*), red-breasted nuthatch (*Sitta canadensis*), red squirrel (*Tamiasciurus hudsonicus*), and chipmunk (*Eutamia* spp.)

Craighead (1982), Hammond (1983), and others have documented that black and grizzly bears favor whitebark pine seeds as a food source, primarily during the fall. Bears forage for seeds by pulling on the clusters of cones (from short-growth-form trees) or, more commonly, by ingesting the contents of squirrel caches.

The degree to which birds and squirrels affect the supply of whitebark pine seed is, of course, governed by the seed crop. In a year of low cone production, almost all of the seeds may be eaten, whereas in a bumper crop year a surplus of potentially germinable seeds could be cached. Hutchins and Lanner (1982) estimated the potential effect of one animal or bird to be approximately 129,000 seeds for one Clark's nutcracker and 875,000 seeds for one red squirrel. Predation by red squirrels is probably most important because the squirrels begin harvesting cones in August before the seeds are mature. Storing seeds in caches naturally decreases the area on which pine regeneration could occur.

Seed Germination.--Whitebark pine seed tested under laboratory conditions has shown a viability range of 0 to 50 percent. The viability of seed appears to be related to the developmental stage of the embryo, that is, fully developed embryos germinate more successfully.

The recommended procedure to germinate whitebark pine seeds (U.S. Department of Agriculture 1974) is to soak the seeds in cold water for 1 to 2 days, then store (while damp) in plastic bags at 33 to 41° F (0.5 to 5.0° C) for 90 to 120 days. The resulting germination rate averages about 30 percent. In Canada, where more recent experimentation has been done, Pital and Wang (1980) recommend treating seeds with sulfuric acid and cutting the seed coat. The Canadian tests have shown that seed dormancy in whitebark pine is a major barrier to their use of the species. Pital and Wang stated that if the undeveloped or underdeveloped seeds (usually those harvested too early) could not be effectively removed from the collected seed, it would not be possible to expect more than 50 percent germination even with the acid treatment.

Germination under field conditions has not been documented. Most species in the Rocky Mountains require bare mineral soil, elimiation of competing vegetation, and protection from animal damage. Whitebark pine requires the same conditions.

MANAGEMENT IMPLICATIONS

Managers of lands serving as grizzly bear habitat have the concern for maintaining whitebark pine seeds as a food source and, when possible, increasing whitebark pine seed supplies. Whitebark pine management on the Bridger-Teton National Forest is oriented primarily toward nontimber purposes. Harvest and regeneration objectives on a specific site are therefore determined more by land management choices than by site factors, stand conditions, or both. The site factors or stand conditions, however, may indicate the extent to which land management objectives can be met. The objectives of maintaining or increasing whitebark pine seed as a grizzly food source can be achieved in the following ways:

1. By maintaining or converting important stands of whitebark pine to a healthy condition.

2. By increasing the proportion of whitebark pine in stands.

3. By increasing cone production in existing stands.

4. By reestablishing whitebark pine where it has been lost, expanding the whitebark pine type, or both.

Each of these methods is discussed in terms of short-term (5 to 10 years) effects; long-term effects (longer than 10 years); and whether the situation is in wilderness (part of the Wilderness Preservation System) or nonwilderness. Short-term habitat manipulation seems most critical to develop a larger bear population, but longer-term planning is necessary to maintain these levels.

Improving or Maintaining the Health of Important Stands.

This management option requires identifying the stands that are or that have been used by bears foraging on squirrel caches. The work done by Craighead and others (1982) has helped determine important habitat components, but specific stands still must be identified. It will be difficult to maintain stands in a healthy condition on the Bridger-Teton National Forest because of (1) the age and condition of the stands; (2) the presence of epidemic populations of mountain pine beetle; and (3) the large acreage within the Wilderness Preservation System.

Wilderness Areas.--There is a potential conflict between current wilderness fire management prescriptions, which allow fire to play its natural role in the ecosystem, and maintaining stands for grizzly bear use. In the short term it may be necessary to alter fire management area prescriptions to include the protection of stands important to bears. In the longer term, fire could be used to convert decadent old stands to younger age-classes for future bear food sources. There may be long regeneration periods (40 to 50 years) if entire stands are lost to insects, or fire. The use of artificial regeneration (planting) perhaps could be approved for a threatened species; however, the cost of such an operation would be high.

Nonwilderness Areas.--In areas outside proclaimed wilderness there are more options to ensure stand perpetuation. If the stands are accessible and intermingled with those planned for timber harvest, the opportunities increase because harvest, thinning, and artificial regeneration can be used to increase the health and vigor of the stands. The inaccessible areas, or those removed from access for a long time, could be managed as those in proclaimed wilderness.

Increasing the Proportion of Whitebark Pine in Mixed Stands

This method is considered effective only in the short term in stands outside proclaimed wilderness and planned for timber harvest, although there may be limited opportunity within proclaimed wilderness. The techniques for increasing the proportion of whitebark pine in a stand are common regeneration practices that should be outlined in a silvicultural prescription. Two regeneration methods appear feasible for perpetuating the whitebark pine component of existing stands. They are:

1. Natural, through favoring advance regeneration.

2. Artificial, through bare root or containerized planting stock or direct seeding.

Natural Regeneration.--The opportunity for natural regeneration from seed fall has been described previously. Closely coordinating site preparation with a good cone crop may increase regeneration success. A large cone crop would likely be necessary to yield seed in excess of that which birds and rodents usually consume.

Protecting advanced natural regeneration might help increase the whitebark pine population. Local observations indicate that although small clumps of regeneration may occur, the generally low quality of seedlings eliminates them as a significant regeneration source. If, however, a portion of a mixed stand did contain sufficient seedlings, practices such as winter logging could be used to protect them from undue damage during skidding. This strategy would be feasible where pole or sapling stands exist, but because of the advanced age of most stands, at least on the Bridger-Teton National Forest, this approach will seldom be practical.

Artificial Regeneration.--Although four potential methods of artificial regeneration exist, only one --planting--is presently practical.

1. Seed transfer. No documented work has been done on seed transfer of whitebark pine; however, we do know that seed should not be transferred to a site with more severe environmental conditions than those where the seed was collected. It would also be prudent to be narrowly restrictive to elevation zones and geographic locations until more is known.

Cones should be collected after they have changed from purple to a dull brown. The seeds should be cut to ensure that the embryo is well developed, which will mean most collections will take place after Sept. 1. The cones are most effectively collected by felling or climbing upright trees. Short, shrubby trees could be harvested with cone hooks. If any consistent collection from standing trees is to be made, the cones would need some sort of protection from squirrel and bird predation. Although collection from squirrel caches would be the easiest method, it would yield the least predictable seed.

2. Direct seeding. Seed losses from animals and birds, coupled with unpredictable germination, make direct seeding the least desirable artificial regeneration method. Direct seeding has been successful for other species, however. If these difficulties can be overcome, this method may become feasible for whitebark pine.

3. Planting. Planting is at present the only practical method of artificial regeneration. There are basically two types of planting stock available: bareroot or containerized. The extensive local knowledge and experience in the use of bareroot seedlings that has been gained with other native species would be valuable in the planting of bareroot whitebark pine. The techniques are fully covered in the USDA Forest Service's Region 4 Reforestation Handbook. The use of containerized seedlings in this area has been limited; however, such experience with other species is extensive throughout the West.

4. Germinant. Buchanan and Develise (1978) reported a relatively new approach to artificial regeneration, that of using germinated seeds. They conducted tests with ponderosa pine and Coulter pine, which are relatively large-seeded species. The survival rate was good when they covered the seedlings with protective caps. I have had similar experience using plastic cones to protect direct-seeded seedlings. This practice could be used on germinants as well. Tinus (1984) has suggested that using germinants to get just one seedling per container for containerized seedlings is a viable technique.

Regardless of the method of artificial reforestation, adequate site preparation is essential. Bare mineral soil needs to be cleared from a spot of a minimum of 18 by 18 inches. On droughty sites, or where more shrubs exist, a larger spot will be needed. It is also important to plant as soon after snowmelt as possible to make available as much moisture as possible.

Increasing Cone Production

The technology and expertise exist to increase cone production on a long- or short-term basis and within or outside of wilderness areas. The techniques that are used in seed production areas--thinning, fertilization, and protection from insects--could be used in whitebark pine stands as well. Practically speaking, however, it would be difficult to increase seed production over large areas. On an individual stand basis, thinning could be used. The application of any technique would require a thorough examination of grizzly bear use as well as of stand conditions and characteristics. Fenley (1969) and Kendall (1983), have observed the importance of considering the conditions which favor perennial caching by red squirrels. The red squirrel, as observed by Kendall (1983), may provide a large enough concentration of whitebark pine seeds to be periodically important to grizzly bears.

Reestablishing or Expanding Whitebark Populations

The opportunities for this way of maintaining or increasing whitebark pine as a grizzly bear food source are similar to that described under the heading of Increasing the Proportion of Whitebark Pine in Mixed Stands.

In some situations it may be desirable to extend the distribution of whitebark pine or to replace stands destroyed by fire or insects in wilderness and nonwilderness areas. An example might be an area with no commercial timber value that had been frequented by bears that foraged on squirrel caches containing whitebark pine cones. These stands would probably be on exposed ridges and consist of short, shrubby multistemmed trees near stands of spruce and subalpine fir. Seed could be collected from these stands with an objective of selecting trees with good production. The seeds could be sown in the nursery and outplanted at the periphery of the existing stands or in other adjacent areas that had contained whitebark pine as a component.

CONCLUSIONS AND RECOMMENDATIONS

In summary, in the short term we should use proven silvicultural techniques to maintain or increase whitebark pine seed production in existing stands. In the long term we may be able to extend the presence of whitebark pine primarily through artificial regeneration, even though this strategy is not immediately available. The technique will become feasible if consistently high-quality seedlings can be produced.

Future research on whitebark pine should focus on the following areas:

1. Improving our knowledge and skill in nursery propagation of seedlings.

2. Defining further the silvicultural practices that will enhance cone and seed production.

3. The relationship of other tree species to the long-term maintenance of red squirrels in a vicinity to ensure whitebark pine seed is concentrated for grizzly bear use.

4. The current rate of replacement (natural regeneration) in existing stands.

REFERENCES

Amman, Gene D.; Baker, H.; Trostle, Galen C. Res. Note INT-151. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1971. 7 p.

Amman, Gene D. Characteristics of mountain pine beetles reared in four pine hosts. Environmental Entomology. 11(3):590-593; 1982.

Bailey, D. K. Pinus albicaulis. Curtiss Botanical Magazine. 180(3): 141-147; 1976.

Buchanan, Bruce A.; Develice, Robert L. Germinant reforestation: a promising new technique. Journal Article No. 644. Las Cruces, NM: New Mexico Agricultural Experiment Station; 1978. 4 p.

Collingwood, G. H.; Brush, W. D. Knowing your trees. Washington, DC: The American Forestry Association; 1964. 349 p.

Craighead, John J.; Scaggs, G. B.; Sumner, J. S. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Wildlands Institute Monograph No. 1. Missoula, MT: University of Montana; 1982. 279 p.

Daniel, Theodore W.; Helms, John A.; Baker, Frederick S. Principles of silviculture. New York, NY: McGraw-Hill Book Company; 1979. 500 p.

Dobbs, R. C.; Edwards, D. G. W.; Konishi, J.; Wallinger, D. Guidelines to collecting cones of B. C. conifers. Joint Report No. 3. Victoria, BC: British Columbia Forest Service, Canadian Forestry Service; 1976. 98 p.

Finley, Robert B, Jr. Cone caches and middens of Tamiasciurus in the Rocky Mountain Region. In: Jones, J. K., ed. Contribution in mammalogy. Manhattan, KS; 1969. 233-272.

Gruell, George E. Fire's influence on wildlife habitat on the Bridger-Teton National Forest, Wyoming. Volume 1 - Photographic record and analysis. Res. Pap. INT-235. Odgen, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 207 p.

Hall, Peter J. Survival and growth of exotic Pinus: species in central Newfoundland ten years after planting. Information Report N-X-154. St. John's, NF: Newfoundland Forest Research Centre; 1977. 12 p.

Hammon, Forrest M. Food habits of black bears in the Greys River drainage, Wyoming. Laramie, WY: University of Wyoming and Wyoming Game and Fish Department; 1983. 50 p.

Hiratsuka, Y.; Maruyama, P. J. Castilleja miniata, a new alternate host of Cronartium ribicola. Plant Disease Reporter. 60(3):241; 1976.

Hoff, R.; Bingham, R. T.; McDonald, G. I. Relative blister rust resistance of white pines. European Journal of Forest Pathology. 10:307-316; 1980.

Hutchins, H. E.; Lanner, R. M. The central role of Clark's nutcracker in the dispersal and establishment of whitebark pine. Oecologia. 55:192-201; 1982.

Kasper, J. B.; Szabo, T. The physical and mechanical properties of whitebark pine. Forestry Chronicle 46(4):315-316; 1970.

Kellogg, R. M.; Koeppen, R. C.; Miller, R. B.; Rowe, S. Identification of the wood of the soft pines of western North America. IAWA Bulletin. 3(2):95-101; 1982.

Kendall, K. C. Use of pine nuts by grizzly and black bears in the Yellowstone area. In: Meslow, E. Charles, ed. Bears: their biology and management: Fifth international conference on bear research and management; 1980; Madison, WI: International Association for Bear Research and Management; 1983: 166-173.

Pital, J. A.; Wang, B. S. P. A preliminary study of dormancy in Pinus albicaulis seeds. Canadian Forest Service Bi-Monthly Research Notes. 36(1): 4-5. 1980.

Steele, Robert; Cooper, Stephen V.; Ondov, David M.; Roberts, David W.; Pfister, Robert D. Forest habitat types of eastern Idaho-western Wyoming. Gen. Tech. Rep. INT-144. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 1983. 122 p.

Stein, William I. Prospects for container-grown nursery stock. In: Baumgartner, David M., ed. Tree planting in the Inland Northwest: short-course proceedings; Pullman, WA: Washington State University, Pullman, WA. 1976. 89-103.

Tinus, R. W. Physiology research made forestation with container-grown seedlings successful. In: New forests for a changing world: Proceedings; 1983. Portland, OR. Washington, DC: Society of American Foresters; 1984. 398-404.

Tomback, Diana F. Notes on cones and vertebrate mediated seed dispersal of Pinus albicanis (Pinaceae); Madrono. 28:91-94; 1981.

U.S. Department of Agriculture. Diseases of forest and shade trees of the United States. Agric. Handbook 386. Washington, DC; 1971. 658 p.

U.S. Department of Agriculture. Seeds of woody plants in the United States. Agric. Handbook 450. Washington, DC; 1974. 883 p.

U.S. Department of Agriculture. Western forest insects. Misc. Publ. 1339. Washington, DC; 1977. 654 p.

U.S. Department of Agriculture. Ecology and regeneration of lodgepole pine. Agric. Handbook 606. Washington, DC; 1983. 51 p.

Weaver, T.; Dale, D. Pinus albicaulis in central Montana: environment, vegetation and production. The American Midland Naturalist. 92(1):22-230; 1974.

ENHANCING GRIZZLY BEAR HABITAT THROUGH TIMBER HARVESTING

Mike Hillis

ABSTRACT: On the Lolo National Forest in western Montana, drainage forbfields and other very moist habitat components are given special management emphasis because of their relative scarcity and sensitivity to management. Desired grizzly bear foods commonly found in drainage forbfields have been observed on certain microsites within clearcuts. Closer examination revealed that broadcast-burned clearcuts in poorly drained subalpine fir/clintonia or subalpine fir/bluejoint habitat types produced vegetative communities similar to drainage forbfields. Based on these observations, two timber sales were initiated within essential grizzly bear habitat to test the validity of these observations. Vegetative conditions will be monitored following treatment to test the forb response. Unlike drainage forbfields, shrubfield/cutting units are a common habitat component throughout the Lolo National Forest. Producing desirable grizzly bear foods by logging Douglas-fir/blue huckleberry, grand fir/beargrass, and other habitat types is a fairly predictable process. Grizzly bear habitat management strategies in such situations should be based on avoiding human-caused mortality and scheduling timber harvest so that the area produces a sustained, even flow of grizzly bear foods within cutting units. This latter strategy can be achieved by (1) inventorying timber stand age classes in the project area; (2) sampling existing units of varying ages in the area to determine the average period in which grizzly bear foods are produced following treatment; and (3) determining the optimal long-term harvest entry interval and treatment intensity.

INTRODUCTION

Because there are no documented instances in which habitat manipulation has directly produced more grizzly bears, managers do not readily accept the idea of enhancing grizzly bear habitat with timber harvest. On the Lolo National Forest, we believe we can safely implement the concept if we avoid creating disturbances and human-caused mortality of habitat. The argument that "we don't know enough" to enhance grizzly bear habitat may not be defendable for two reasons: (1) many of the Forest's inventoried habitat components occur in seral or disturbance-related situations (Cline and others 1984; Tirmenstein (1982) and (2) our knowledge of habitat type response to certain silvicultural treatments is good (Arno and others 1985; Pfister and others 1977). Thus, if certain seral plant communities provide good grizzly bear habitat and if we can predictably create those communities without increasing the risk of mortality, then habitat enhancement is an appropriate management goal.

On the Lolo National Forest, habitat enhancement is one of our recovery strategies, secondary only to minimizing mortality. On our reasonably productive nonwilderness sites, we have two Forest Plan allocations that use timber harvest, prescribed fire, or both to enhance habitat. Although no one knows exactly how to artificially create optimal habitat for grizzly bears, we are experimenting with several types of enhancement. Two of the more promising types are treating wet microsites to create artificial drainage forbfields and a technique for scheduling timber harvest in potential shrubfield/cutting units.

WET MICROSITES

The Lolo National Forest shares a portion of the Cabinet-Yaak and north Continental Divide grizzly bear ecosystems. It is evident from 3 years of habitat component mapping that the Lolo National Forest has some of the poorer, drier parts of both ecosystems (Cline and Tirmenstein 1984). There are two reasons for this: less precipitation and disproportionately more well-drained soils within the grizzly bear ecosystems (Sasich 1984). "Wet" habitat components, such as drainage forbfields and wet meadows, are particularly scarce on the Lolo National Forest. Because these components are important as spring and midsummer food sources, management of these components and other comparable wet components has been given a special management priority. Managers often consider drainage forbfields to be a semipermanent "climax" vegetative feature, but Lolo National Forest personnel have observed grizzly bear foods, such as *Veratrum viride* (northern false-hellibore), *Heraculum lanatum* (common cowparsnip), and *Angelica arguta* (angelica), which normally occur in drainage forbfields, in large concentrations within clearcuts. This finding raises two questions: (1) Why does that positive vegetative response occur? and (2) Is it possible to deliberately create those vegetative communities? The first logical step in answering these questions was to sample those clearcuts to see what kind of common characteristics they shared.

After 3 years of vegetative sampling, it appears that there are indeed some common characteristics

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Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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in these sites. Typically, a clearcut that had a "drainage forbfield" in the middle had these characteristics:

1. The clearcut was very large and included several different habitat types,

2. Geographic features, including swales, slumps, and areas immediately behind small terminal moraines, were significantly more poorly drained than in the surrounding area.

3. Habitat types within these poorly drained microsites were often, but not always, subalpine fir/clintonia-clintonia (ABLA/CLUN-CLUN), subalpine fir/bluejoint-bluejoint (ABLA/CACA-CACA), or subalpine fir/bluejoint-bedstraw (ABLA/CACA-GATR).

4. The wet microsite was heavily scarified. In all cases, the clearcut had a high fuel load and was broadcast burned.

5. Although the wet microsite had enough stumps to indicate that the site was at one time fully stocked, the water table had risen following harvest to the extent that conifer regeneration was nonexistent for up to 25 years.

The relationship among these characteristics was not evaluated statistically; however, few exceptions were found. In looking at these common characteristics, it appears possible to create drainage forbfields by harvesting timber from midelevation timber communities where ABLA/CLUN or ABLA/CACA habitat types are found. It is fairly common in certain land types on the Lolo National Forest to encounter pockets of poorly drained soils. It thus appears that when these sites are forested, tree removal, accompanied by scarification, could produce productive forb communities.

In designing a timber sale program to create such microsites, however, several problems have been encountered. For instance, where the wet site is very small (less than 1 acre) habitat type indicators may be difficult to find. In such cases, conifers may be tying up the available moisture to the extent that vegetative indicators, such as clintonia, are almost nonexistent (Sasich 1984). In such cases, topographic features such as slumps or swales may be the only indication of available subsurface moisture. Another problem we have noted is that there is considerable variability in how given habitat types, particularly ABLA/CLUN (all phases), respond. For instance, ABLA/CLUN-CLUN at the drier extreme produces many shrubs, including _Sorbus sitchensis_ (sitka mountainash) and _Cornus occidentalis_ (western dogwood). Although these plants are excellent grizzly bear foods, the more plentiful of the two, dogwood, occurs under a canopy; hence timber harvest in this moisture regime may not be beneficial. Forb-dominated conditions seem to occur only at the wet end of ABLA/CLUN-CLUN, where the site is too wet for shrubs. Even at the wet end, however, _Alnus sitchensis_ (alder) may dominate the community after treatment if present in the pretreatment understory and may inhibit the forb response. Getting a forb-dominated community after treatment may still be possible in such situations if the site can be scarified. Losensky (1983) has noted that in very wet sites tractor-piling of slash will temporarily eliminate alder and thus allow the site to be occupied by forbs and grasses. Unfortunately, this poses another problem because it is not always possible to burn or mechanically scarify wet areas. One possible solution is to mechanically scarify the site immediately after logging, before the water table has risen appreciably. Also, the technological jump in burning difficult moist habitat types during the summer may help to solve the problem.

Lolo National Forest has initiated a timber harvest program in essential habitat on a variety of sites to test forb response potential. The program is designed to take into account the problems previously described. Treatment areas have been selected based on the following criteria: (1) bear units in the area have an inherent scarcity of drainage forbfield or other "wet" components; (2) land types have a high potential for having wet microsites in ABLA/CLUN or ABLA/CACA habitat types; (3) merchantable and marketable stands are present; and (4) disturbance and an increased risk of human-caused bear mortality can be avoided.

Two sales were identified that could meet these criteria if their boundaries were extended. Wet sites were identified that could produce forb or sedge communities if treated. Several 2- to 4-acre clearcuts were designated for treatment within this area. These treatment opportunities were incorporated into project Environmental Analyses (EA's). One EA has been approved, and one EA is pending. A number of constraints in the project plans are designed to avoid disturbance and mortality. These included seasonal operating constraints (no activity during periods of probable bear use) and stringent requirements on postsale road management. Pretreatment and posttreatment monitoring on the "forb units" will include an inventory of all plants on the sites by species and crown density. Posttreatment monitoring will be done for 5 years. Scarification levels will also be measured on those sites that were scarified. Forb response will be compared with the pretreatment vegetative data so that the results can be determined.

DISCUSSION

It will be several years before we have any conclusive results on forb response. Based on past observations, I think the question is not whether the sites respond favorably, but to what degree and whether the response is worth the effort. One interesting option of the project will be to look at long-term tree regeneration surveys to see if increased water tables can successfully delay regeneration. Based on observations, it appears likely that we will not get any appreciable regeneration for 30 to 40 years. If so, this will make the treatments more cost effective since the benefits will be fairly long term. The essential criterion for any treatment is, however, will it benefit the bear? Assuming that (1) mortality risks are not

increased (and in both projects we have taken significant measures to ensure that does not happen); (2) disturbance is avoided; and (3) a scarce food supply is increased within a bear unit, the least we can say is "it can't hurt." I think logically such treatments may in the long run contribute to recovery.

SHRUBFIELD/CUTTING UNITS

Many of the well-drained midelevation sites on the Lolo can be classified as shrubfield/cutting units components if regenerated and scarified (either with burning or mechanical piling). Habitat types that respond especially well (from the berry-producing shrub standpoint) include Douglas-fir/blue huckleberry (PSME/VAGL), subalpine fir/beargrass/blue huckleberry (ABLA/XETE/VAGL), and grand fir/beargrass (ABGR/XETE) (Arno and others 1985; Pfister and others 1977). Thus, it is a simple matter to produce berry-producing shrub communities, most of which provide some type of bear food, if we clearcut (or seed-tree cut) and broadcast burn such areas. Some of the typical shrubs that will be abundant after treatment include Sambucus spp. (elderberry), Sorbus sitchensis (sitka mountainash), Amelanchier alnifolia (Saskatoon serviceberry), and Sheperdia Canadensis (russet buffaloberry). I have excluded Vaccinium spp. (huckleberry) because it responds better if stands are partially cut and not burned (Minore and others 1979; Miller 1977), which makes it somewhat different than the other shrubs. By harvesting timber in these types and taking precautions to avoid grizzly bear disturbances and mortality, it is easy for land managers to delude themselves into thinking that they are doing everything possible for the bear. Unfortunately, unless managers are willing to provide a continual flow of this food source over time, treatment may not be beneficial.

The following example shows how opportunities for habitat enhancement can be forgone when managing this vegetative type. The "shrub life" in regeneration units, or the period in which berry-producing shrubs are a major vegetative component after logging, varies. Let us assume that clearcuts within a given bear unit have an average shrub life of 30 years. If the timber age classes were predominantly old growth, and we liquidated those stands in 40 years (assuming we could at the same time retain adequate amounts of cover and security), we would exhaust our transitional berry-producing options in 70 years (40 + 30). Faced with a 110-year rotation, we would have 40 years of relatively sterile pole stands and no shrubfield components.

The way around this problem is to schedule timber harvest to optimize this food source over time. Although the solution may appear obvious, it is one that is often overlooked when we are faced with the immediate need to minimize disturbance and mortality. On the Lolo National Forest, we have developed a simple model that involves (1) inventorying all timber stands that have shrubfield potential by age class; (2) sampling cutover stands to determine "shrub life"; and (3) developing, using age class histograms, an optimal harvest schedule that produces an even flow of shrubfield cutting units. The product of this model is a harvest strategy that identifies the number of entries needed over time, the average acres harvested per entry, and the optimal interval between entries.

On a 10,000-acre project area where the system was practiced, the model has worked like this:

1. Timber age class data, collected by Timber Stand Inventory crews, and secondarily in non-inventoried stands by photo interpretative maps, were categorized by successional stage (fig. 1).

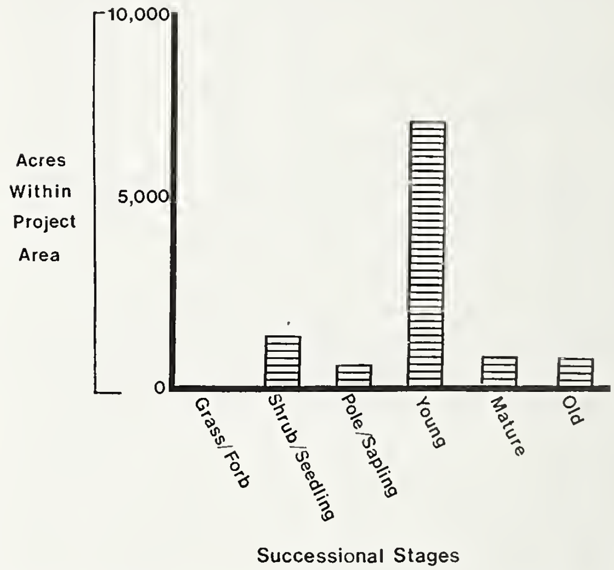

Figure 1.--Timber age-class distribution by successional stage within a sample project area.

2. Existing clearcuts in the area were sampled for berry-producing shrubs. A subjective rating was given for individual shrubs based on their relative level of vigor. Clearcuts harvested in the 1970's showed significantly higher levels of shrub vigor than units harvested in the earlier 1960's, although the latter were still producing berries at higher levels than uncut stands. Based on this analysis, it was assumed that units in the area had an approximate "shrub life" of 30 years.

3. If the 30-year shrub life is compared with the current age class distribution (fig. 1), it becomes evident that timber harvest will be necessary to retain the shrub community. In other words, as the 20-year-old clearcuts mature and no longer produce berries, no grass/forb communities are available to replace this food source. A number of different harvest intensities and entry intervals were tested by developing histograms to see which harvest option would produce the most sustainable levels of shrubfield/cutting unit components over time. Additional criteria, including optimal marketable sale size, were imposed to ensure that the optimal

strategy for producing grizzly bear foods was compatible with timber industry marketing needs. From the bear food standpoint, the most effective harvest program is one that (1) clearcuts 900 acres (in 10 30-acre units) every 20 years from a 70- to 90-year-old larch and lodgepole component; (2) defers treatment from 400 acres of old growth because the area is associated with some riparian cover corridors; and (3) defers treatment, for 60 years, in 700 acres of commercially thinned 70-year-old larch because of status as a desirable timbered vaccinium habitat component. If the last scheduled entry is made in 60 years, this program would provide bear food for 90 years, at which time existing clearcuts would be ready for the next treatment. Figure 2 shows various age classes available by time period; the critical elements are maintaining the shrub/seedling age class and maintaining older age classes that can be clearcut to create rich shrub/seedling communities.

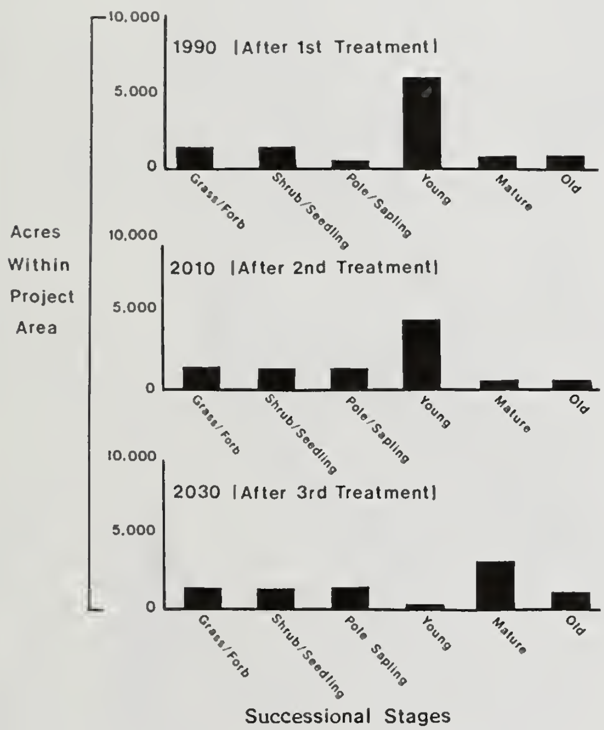

Figure 2.--Tree age-class distribution through the year 2030 that is achieved by harvesting 900 acres of timber from the young age class every 20 years. Note the perpetuation of shrub/seedling communities which produce shrubfield/cutting unit habitat components.

DISCUSSION

This method appears simplistic, because in practice many other factors, including the avoidance of timber age classes susceptible to mountain pine beetle outbreaks and the protection of other grizzly bear habitat components also affect project design. Even so, it should be evident that in situations where a majority of bear foods are "transitional" and are stimulated through timber harvest, the capacity to sustain these transitional foods should be considered in long-term harvest planning. Long-term monitoring will test the final appropriateness of this strategy.

REFERENCES

Arno, S. F.; Simmerman, D. G.; Keane, R. E. Forest succession on four habitat types in western Montana. General Technical Report INT-177. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1985. 74 p.

Cline, M.; Tirmenstein, D. A. Grizzly bear habitat mapping. 1984. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Lolo National Forest, Missoula, MT.

Losensky, B. J. Summary of grizzly bear food responses on midelevation sites. 1983. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Lolo National Forest, Missoula, MT.

Miller, M. Response of blue huckleberry to prescribed fires in a western Montana larch-fir forest. Research Paper INT-188. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 33 p.

Minore, D.; Smart, A. W.; Dubrasich, M. E. Huckleberry ecology and management research in the Pacific Northwest. General Technical Report PNW-93. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1979. 50 p.

Pfister, R. D.; Kovalchik, B. L.; Arno, S. F.; Presby, R. C. Forest habitat types of Montana. General Technical Report INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Sasich, J. L. Lands system inventory--Lolo National Forest. Missoula, MT: U.S. Department of Agriculture, Forest Service, Lolo National Forest; (in preparation).

Tirmenstein, D. A. Grizzly bear habitat and management in the Rattlesnake National Recreation Area and Wilderness. Missoula, MT: University of Montana; 1983. 213 p. M.S. thesis.

GRIZZLY BEAR HABITAT COMPONENTS ASSOCIATED WITH PAST LOGGING PRACTICES ON THE LIBBY RANGER DISTRICT, KOOTENAI NATIONAL FOREST

Alan A. Bratkovich

ABSTRACT: Seventy cutting units harvested from 1950 to 1980 and ranging in size from 5 to 200 acres were evaluated for the occurrence of bear foods. Units were treated with various silvicultural and site preparation methods and occurred in various habitat types on grizzly bear spring, summer, and fall range. Timber harvest occurred on both Forest Service and private land with no documented intent of benefiting grizzly habitat at the time of harvest. Habitat component mapping and data from 1/10 acre vegetative plots suggest that certain conditions enhanced bear food production. Grizzly habitat components, including riparian stream bottom, wet meadow, dry meadow, and mixed shrubfield cutting units, resulted from timber harvest. Observations indicate that timber harvest and site preparation methods on certain sites can enhance bear food production.

INTRODUCTION

The east side of the Cabinet Mountains is characterized by glaciated U-shaped drainages that drain east into the Libby Creek valley bottom (fig. 1). Approximately 100,000 acres are mapped as grizzly bear habitat, management situation 1 (Kootenai National Forest 1985). Use of the area by black bears (Ursus americanus) and grizzly bears (Ursus arctos horribilis) is documented throughout.

Most timber harvest activities on National Forest land along the east slope of the Cabinets began in 1960; about 70 million board feet of timber were harvested on approximately 100 cutting units during the sixties and seventies. The predominant silvicultural treatment was clearcutting, with precommercial and commercial thinning occurring to a lesser degree along with overstory removal and group selection cuts. Site preparation methods include dozer piling with machine scarification and broadcast burning. The sites of some thinning units and overstory removals and group selection cuts were not treated. Except for a few parcels of private land and several patented mining claims, the area is part of the Kootenai National Forest administered by the Libby Ranger District.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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To better coordinate unit layout and harvest and site preparation methods for the purpose of enhancing bear foods, we attempted to determine if, or to what extent, past timber harvest activity increased bear food production on various sites in grizzly habitat. We gathered information on the composition and ground coverage of recognized bear foods in the cutting units and the adjacent untreated areas in order to compare the quantity and quality of bear foods in treated and untreated areas.

Data and observations compiled to date indicate that some timber harvesting appeared to positively influence bear food production; some cutting units were subsequently mapped as grizzly habitat components. Habitat components and mapping procedures are taken from Madel (1982) and have subsequently been adopted by the U.S. Department of Agriculture, Forest Service, Northern Region.

METHODS

Habitat component mapping precedures substantiated with 1/10-acre vegetative plots (Madel 1982) were used to evaluate past logging units and untreated mature coniferous stands. The objective was to evaluate and compare bear food production in logged units and in adjacent untreated conifer stands with similar site parameters, including habitat type, slope, aspect, and elevation. Information on cutting unit history, including harvest date and type, site preparation date and type, and habitat type, was recorded for units located in grizzly bear habitat along the east Cabinet Mountain face. This information was taken from the Libby Ranger District Timber Stand Improvement Data Base and then field-checked for verification. Forest habitat types from Pfister (1977) were also recorded for a more complete description of site potential and productivity. Madel (1982) provides a complete species list of bear foods by habitat components for the Cabinet Mountains.

Sampling of cutting units and adjacent untreated areas in delineated grizzly habitat began at Granite Creek and systematically proceeded south to West Fisher Creek (fig. 1). Units felt to be representative of the site were stratified and sampled regardless of ownership. One-tenth-acre circular plots with a radius of 35.8 ft. were located inside cutting units in areas felt to be representative of the ground vegetation in the unit. The same criteria were used for sampling the ground vegetation in the adjacent conifer stands. A complete species list including percent canopy coverage, along with vegetation structure,

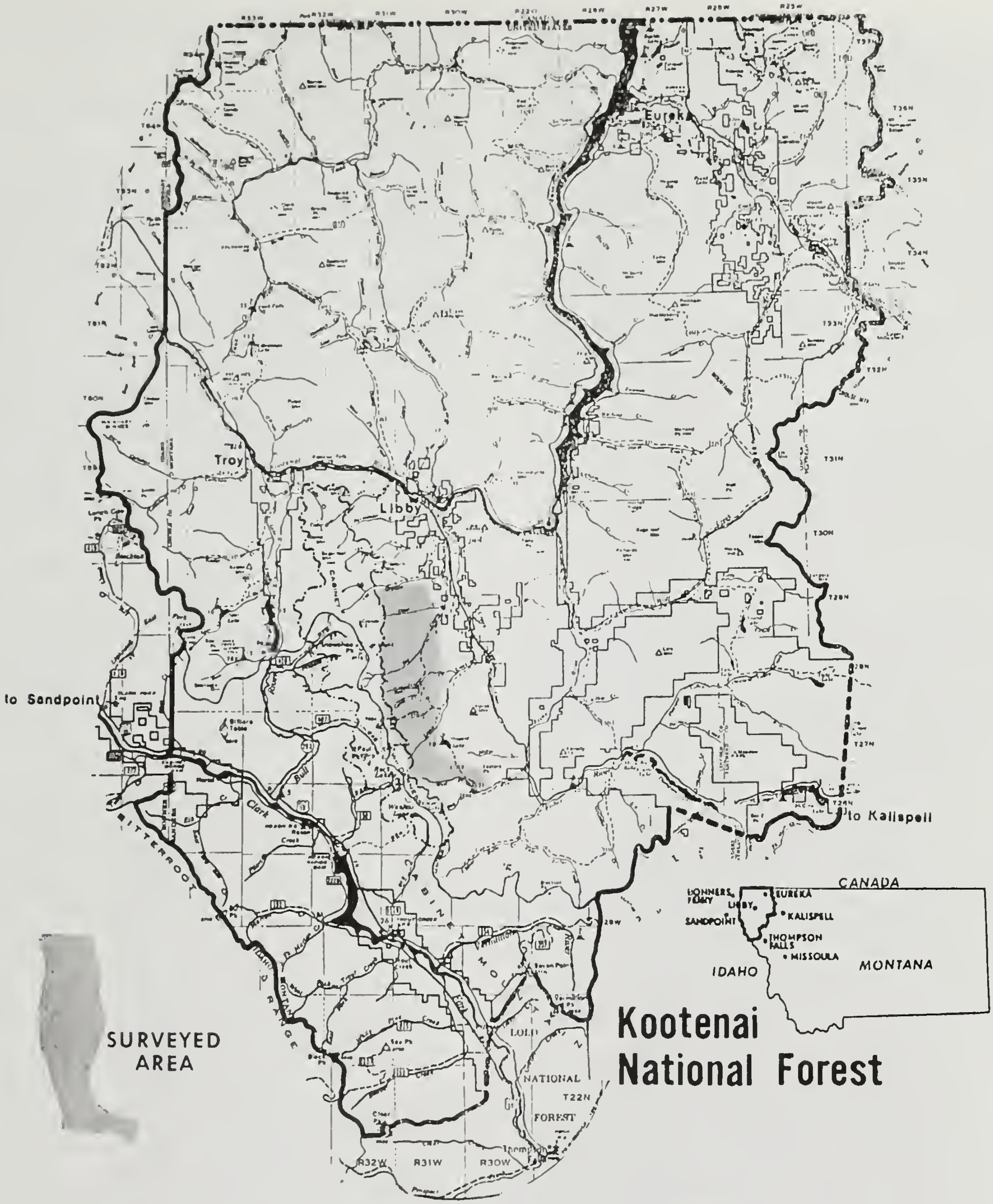

Figure 1.--Surveyed area along the east front of the Cabinet Mountains.

elevation, aspect, slope, and canopy closure as determined by spherical densiometer readings, was recorded for each site. Madel (1982) provides a complete precedural description.

A coverage class of 3, indicating that 25 to 50 percent of the ground surface area of the plot was covered by a particular bear food plant species, generally was considered a desirable forage condition. This determination was made after analyzing coverage classes of bear foods within like, naturally occurring components in the Cabinet Mountains. Bear foods in the next lower coverage class of 2 (5 to 25 percent) generally were not considered sufficient to be classified as a foraging site. This category had to be viewed cautiously, however, because the presence of several bear food plant species within a given plot, each approaching 25 percent coverage, sometimes warranted classification as a desirable foraging condition.

Forty-five units were sampled with vegetative plots, and 25 units were sampled by a walk-through transect without taking plots. The walk-through transect differed from vegetative plots only in that observers visually estimated representative sites without recording coverage classes of bear foods. Observers then subjectively evaluated the value of the unit or site as a foraging component. This was done to expedite sampling only when an experienced evaluator had sampled enough to make accurate estimations.

The number of plots per unit varied in relation to size of unit and uniformity of ground vegetation. Areas with fairly consistent bear food plant species or units of small size were not sampled as intensively as very large units or units where the occurrence of bear foods was discontinuous.

In total, 70 units were evaluated for the occurrence of bear foods, along with 80 sites in adjacent uncut stands. Sites on either side of a cutting unit were occasionally sampled for a more accurate representation, thus accounting for the greater number of sites in uncut stands. Statistical analysis was not used to evaluate or compare data.

RESULTS AND DISCUSSION

Of the 70 cutting units evaluated, 30 had sufficient bear foods to subsequently be mapped as grizzly habitat components (table 1). The main criterion used to determine whether a site supplied adequate foraging value was the occurrence of at least two bear foods at a coverage class of 3 (25 to 50 percent) each as analyzed from the vegetative plots. Another criterion was the dominance of one bear food with a plot coverage of over 40 percent and its subsequent classification within a coverage class of 3 or 4 (50 to 75 percent). Graminoids in the wet meadow or sidehill park component more typically met this criterion. Consideration was also given when three or more bear foods occurred at a coverage class of 2 (5 to 25 percent) with coverages at the upper end of the spectrum close to 25 percent. Madel (1982) discusses the use of other general criteria.

Table 1.--Data from 30 units producing sufficient bear foods to be mapped as habitat components

Resulting habitat component[1]	Cutting unit	Topographic location Elev.	Aspect	Slope	Harvest type[2]	Year	Site preparation[3]	Habitat type[4]	Area
		Ft	Degrees	Percent					Acres
Riparian stream bottom	E11	3,000	-	0	CC	1979	DP/MS	TSHE/CLUN	5
Riparian stream bottom	E12	3,080	-	0	CC	1979	DP/MS	TSHE/CLUN	3
Riparian stream bottom	E22	3,500	90	25	CC	1969	BB	TSHE/CLUN	32
Riparian stream bottom	C500	4,000	-	0	CC	1962	None	ABLA/CLUN	65
Riparian stream bottom	B10	4,000	-	0	CC	1973	DP/MS	TSHE/CLUN	15
Wet meadow	C666	3,600	-	0	CC	1951	BB	TSHE/CLUN	50
Dry meadow	E9	3,500	135	25	CC	1979	DP/MS	TSHE/CLUN	32
Dry meadow	E28	3,200	90	5	CC	1980	DP/MS	TSHE/CLUN	10
Dry meadow	C140	3,400	-	0	CC	1970	BB	TSHE/CLUN	89
Dry meadow	C127	4,000	90	10	CC	1968	DP/MS	TSHE/CLUN	107
Dry meadow	C126	3,700	-	0	CC	1968	BB	TSHE/CLUN	38
Mixed shrubfield	E4	3,700	90	20	CC	1966	BB	TSHE/CLUN	24
Mixed shrubfield	E5	3,400	90	15	CC	1966	DP/MS	TSHE/CLUN	80
Mixed shrubfield	E19	3,400	90	15	CC	1966	BB	TSHE/CLUN	60
Mixed shrubfield	C124	3,800	45	5	CC	1970	BB	TSHE/CLUN	106
Mixed shrubfield	B9	4,000	90	25	CC	1970	BB	TSHE/CLUN	105
Mixed shrubfield	C400	5,000	180	35	CC	1960	BB	ABLA/XETE	35
Mixed shrubfield	B20	4,300	135	10	CC	1960	DP/MS	TSHE/CLUN	10
Mixed shrubfield	B25	4,400	135	10	CC	1960	BB	TSHE/CLUN	30
Mixed shrubfield	B26	4,500	135	30	CC	1960	DP/MS	TSHE/CLUN	20
Mixed shrubfield	B15	4,300	315	20	CC	1973	BB	TSHE/CLUN	10
Mixed shrubfield	D200	4,200	180	30	PCT.	1967	None	TSHE/CLUN	50
Mixed shrubfield	D300	4,200	180	30	PCT.	1967	None	TSHE/CLUN	45
Vaccinium shrubfield	C15	3,600	45	30	CC	1969	BB	TSHE/CLUN	51
Vaccinium shrubfield	C10	4,200	45	25	CC	1969	BB	TSHE/CLUN	48
Vaccinium shrubfield	C107	4,100	90	15	CC	1969	BB	TSHE/CLUN	48
Vaccinium shrubfield	C136	4,400	45	25	CC	1971	BB	THPL/CLUN	45
Vaccinium shrubfield	C300	5,600	180	40	OSR	1960	None	ABLA/XETE	10
Timbered *Vaccinium* shrubfield	A20	5,000	180	35	CS	1966	SB	ABLA/XETE	20
Timbered *Vaccinium* shrubfield	A22	4,600	135	30	CS	1966	SB	ABLA/XETE	45

[1] From Madel (1982).

[2] CC-clearcut; OSR-overstory removal; PCT-precommercial thin; CS-group selection.

[3] DP/MS-dozer-piled/machine scarified; BB-broadcast burned; SB-spot burning.

[4] From Pfister (1977). TSHE/CLUN-western hemlock/beadlily; ABLA/CLUN-subalpine fir/beadlily; THPL/CLUN-western redcedar/beadlily; ALBA/XETE-subalpine fir/beargrass.

Components identified in the cutting units included riparian stream bottom, wet meadow, and mixed shrubfield cutting units, including huckleberry (Vaccinium globulare) shrubfields and timbered huckleberry shrubfields.

Eighty sites were sampled in adjacent timbered stands having similar site characteristics with no prior treatment (table 3). With the exception of three sites, the understory ground vegetation was depauperate of bear foods mainly due to the dense canopy closure. When succession progresses to the point where shade-tolerant trees become dominant in the canopy, shading can eliminate many species and reduce coverage of even the most persistent forbs to just a trace (Pfister 1977). The only exceptions were in three riparian zone areas where the surface water of natural seeps or braided channels increased soil moisture and appeared to positively influence desirable plant production. Natural openings in the canopy due to tree mortality or blowdown allowed increased light penetration to the forest floor and also appeared to favorably influence plant response.

Areas depauperate of bear foods along stream bottoms are likely to produce desirable spring bear foods, such as wet site forbs and graminoids, if converted to earlier successional stages by total or partial removal of the canopy. Both the riparian stream bottom and wet meadow component resulted from logging activity adjacent to stream channels (table 1). Desirable wet site forbs, ferns, and grasses included cow parsnip (Heracleum lanatum), angelica (Angelica spp.), horsetail (Equisetum spp.), fern species (Polypodiaceae), sedges (Carex spp.), and grasses (Calamagrostis canadensis). Site preparation methods, including broadcast burning and dozer piling with machine scarification, did not appear to be a factor in establishing desirable forbs and graminoids in riparian areas. Only two of the riparian units sampled did not have adequate quantities of bear foods to be mapped as components (table 2); however, these units were sampled only 2 years after site treatment, which may have been a factor in the low occurrence of bear foods. Personal observations of dozer-piled riparian clearcuts along the east Cabinets have indicated that bear foods do not become widespread until 3 or 4 years after treatment.

Harvest units in the warm and moist habitat types in the western hemlock (Tsuga heterophylla) and western redcedar (Thuja plicata) series, and also in the cool and moist habitat types in the subalpine fir (Abies lasiocarpa) series, still had sufficient quantities of bear foods to meet the criteria for a desirable foraging site 10 to 25 years after treatment.

Three hundred acres of clearcuts were dominated by a grass-sedge community and subsequently mapped as a dry meadow component (table 1). Some of the desirable grasses and forbs present included sedges (Carex spp.), bromes (Bromus spp.), orchardgrass (Dactylis glomerata), timothy (Phleum pratense), thistle (Cirsium spp.), and clovers

Table 2.--Data from 40 cutting units not producing sufficient bear foods to be mapped as habitat components

Harvest period	Total no. of units	Topographic location: Riparian (3,000-4,000 ft)	Terrace (3,000-4,000 ft)	Upland (4,001-5,000 ft)	Aspect (°): 0-90	91-180	181-270	271-360	Slope (%): 0-20	21-40	Harvest type[1]: CC	OSR	PCT	Site preparation[2]: BB	DP/MS	None
		Number of units														
1961-65	7	-	7	-	4	2	-	1	7	-	7	-	-	1	6	-
1966-70	16	-	14	2	13	3	-	-	16	-	13	3	-	5	7	4
1971-75	3	-	2	1	2	-	-	1	1	2	3	-	-	1	2	-
1976-80	14	2	10	2	9	5	-	-	9	5	13	-	1	2	8	4

[1]CC-clearcut; OSR-overstory removal; PCT-precommercial thin.

[2]DP/MS-dozer-piled/machine scarified; BB-broadcast burn.

Table 3.--Data from 80 sites sampled in mature conifer stands spatially adjacent to cutting units (only 3 sites were subsequently mapped as habitat components as determined by the quantity of bear foods)

Topographic location	No. sites sampled	Habitat type[1]: TSHE/CLUN	THPL/CLUN	THPL/OPHO	Aspect (°): 0-90	91-180	181-270	271-360	Slope (%): 0-20	21-40	>40	Canopy closure (%): 50-70	70-100
		Number of units											
Riparian 3,000-4,000 ft	34[2]	32	3	9	26	8	-	-	30	4	-	3	31
Terrace 3,000-4,000 ft	40	36	3	1	21	15	-	4	30	7	3	2	38
Upland 4,001-5,000 ft	6	5	1	-	2	4	-	-	-	4	2	-	6

[1]From Pfister (1977). TSHE/CLUN-western hemlock/beadlily; THPL/CLUN-western redcedar/beadlily; THPL/OPHO-western redcedar/devil's club.

[2]Three sites in this sample were mapped as the riparian stream bottom habitat component. One site in each of the three habitat types listed.

(*Trifolium* spp.). Habitat type was western hemlock/beadlily. Both dozer piling with machine scarification and broadcast burning site preparation methods produced desired vegetative response of graminoids and sedges. Some units, currently ceanothus (*Ceanothus* spp.) and alder (*Alnus sinuata*) shrubfields, were treated before 1970 and were depauperate of bear foods (table 2). These units may have had adequate coverages of spring bear foods when in the grass-forb stage, but this could not be conclusively determined. The lack of graminoids and sedges in 15 units harvested between 1970 and 1980 could not be completely explained, although many of these units had high coverages of pinegrass (*Calamagrostis rubescens*) that rapidly invaded the site and may have prevented the establishment of desirable graminoids. Four of these units also had heavy slash accumulations without site treatment, making on-site establishment of bear foods unlikely.

Nineteen units responded well with fruiting shrubs such as huckleberry (*Vaccinium globulare*) and serviceberry (*Amelanchier alnifolia*), along with buffaloberry (*Sheperdia candensis*) and mountain ash (*Sorbus scopulina*) to a lesser degree. These units occurred on the subalpine fir/beargrass/huckleberry habitat type on higher southerly aspects and also on the western hemlock/beadlily/beadlily type on the cooler, better drained, easterly aspects (table 1). Canopy removal on these sites followed by broadcast burning or no site treatment produced the most fruiting shrubs. Components mapped in these units included mixed shrubfields, huckleberry shrubfields, and timbered huckleberry shrubfields.

Martin (1979) states that fruit production generally remains high until the tree canopy exceeds 30 percent cover. Almost 100 percent of the timbered stands located on similar sites and adjacent to the cutting units had tree canopy closure of 70 percent or greater (table 3). Clearcutting, overstory removal, group selection, and precommercial thinning were harvest methods which produced shrubfield components on these sites. The fruiting shrub response in the understory of cutting units with no site treatment appeared to be associated with increased light penetration to the forest floor due to canopy removal. Although huckleberry was present in trace amounts in the understory in many adjacent timbered stands, the shrubs appeared suppressed and unproductive.

Martin (1979) also states that competition from other shrub species can be quite limiting to huckleberry plant cover and berry production. This may account for the fact that the six clearcut units broadcast burned from 1961 to 1970 showed little or no coverage of fruiting shrubs, particularly huckleberry (table 2). These units had high coverages of evergreen ceanothus (*Ceanothus veluntinus*) and redstem ceanothus (*C. sanguineus*), which are both capable of responding prolifically to fire treatment.

Broadcast burning appeared to be the best treatment for encouraging fruiting shrubs. It appeared that heavy scarification of units on the drier, rounded side slopes may have been a factor in preventing desired shrub response. Zager (1980) found that huckleberry plant cover and production was very low in scarified clearcuts, because scarification extensively damages rhizomes, which are the primary storage organs for carbohydrates and nutrients necessary for growth and development.

Data and observations to date indicate that silvicultural treatments on certain sites appear to positively influence bear food production. Evaluation of past cutting and site preparation methods thus enables better coordination of timber sales with seasonal bear food requirements.

ACKNOWLEDGMENT

I would like to acknowledge Mike Madel for his component classification and field work in the Cabinet Mountains along with Maria Ash and Ricia Gittins, who assisted in field work, and Reed Kuennen and Tim Benedict, who helped compile data.

REFERENCES

Kootenai National Forest proposed forest plan. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1985.

Madel, M. Grizzly bear habitat delineation and reconnaissance in the Cabinet Mountains: a procedural description. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1982. 38 p.

Martin, P. Productivity and taxonomy of the *Vaccinium globulare*, *V. membranaceum* complex in western Montana. Missoula, MT: University of Montana; 1979. 136 p. M.S. thesis.

Pfister, R.; Kovalchik, B.; Arno, S.; and Presby, R. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Zager, P. The influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Missoula, MT: University of Montana; 1980. 131 p. Ph. D. dissertation.

GRIZZLY BEAR DIRECT HABITAT IMPROVEMENT ON THE KOOTENAI NATIONAL FOREST

Ernesto R. Garcia

ABSTRACT: Forest management practices on the Kootenai National Forest have profoundly affected the grizzly bear (Ursus arctos horribilis) and its habitat. These effects, of long and short duration, have been both positive and negative. Past efforts to accommodate grizzlies during forest management have been primarily reactive, focusing on mitigation measures such as road closures and activity scheduling restrictions. More recently, biologists have taken a more proactive approach, attempting to directly improve habitat with projects such as patch cutting accompanied by burning and/or seeding of umbels; prescribed burning; road seeding of graminoids and legumes; and planting of berry-producing shrubs. Many of these projects are as yet untested or partially completed. This paper describes these projects and the monitoring methods designed to determine their biological effectiveness.

INTRODUCTION

Within the Cabinet-Yaak Grizzly Bear Ecosystem of northwestern Montana, intensive timber management, in conjunction with other forest activities, has increased the need for adequate and effective mitigation of logging impacts. Forest biologists recognize this need and the importance of promoting the positive effects of habitat manipulation wherever possible. Additionally, projects are being conceived which might augment existing habitat values. In the following examples of such projects, basic considerations in project type and site selection included (1) the potential to produce desired vegetation response (habitat type), (2) juxtaposition of site to existing grizzly habitat components (i.e. placing the project near an area already frequented by bears), (3) ability to control human disturbance, (4) compatibility of land use objectives, and (5) available funding.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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SELECTIVE PATCH CUTTING

Diverse habitats provide a variety of plant communities, each of which may be seasonally important in meeting a bear's total annual needs. Timber harvest, due to its potential to increase habitat diversity, can thus be an effective means of accomplishing bear habitat objectives. Biologists must clearly define these objectives to the timber manager, specifying unit size, location, postsale treatments, and road management requirements. Disturbances associated with open roads may significantly diminish project benefits. Project work and the desired site preparation should be scheduled to optimize vegetation response and to avoid critical seasons of bear use. Biologist participation in all phases of project planning, from documentation of objectives in the Environmental Analysis Report, to formulation of the conceptual design and unit layout, will increase the probability of meeting project objectives.

In the following examples, patch cuts (small clearcuts) were used to increase the size of existing foraging components or to create new ones.

Ross Creek spring range project.--The project site was a densely timbered hemlock/beadlily stand ($\bar{x}$ canopy closure = 98 percent) with predominantly western redcedar (Thuja plicata) overstory and a depauperate understory (less than one percent vegetation ground cover). At an elevation of 2,900 ft (884 m) the site is basically flat and lies adjacent to an open low-gradient stream bottom component within occupied grizzly bear habitat. The component has a heavy cover layer of forbs and graminoids, and is punctuated by several small islands of cedar. Bear foods are abundant and include cow parsnip (Heracleum lanatum, angelica (Angelica spp.), sweet sicily (Osmorhiza chilensis, O. occidentalis), horsetail (Equisetum spp.), falsehellebore (Veratrum viride), and numerous other forbs, grasses, and sedges. The component is heavily used by bears during spring for feeding and day bedding. Project objectives are (1) to increase the size of this high-quality spring range, (2) to determine if artificial seeding will significantly accelerate forage establishment and productivity, and (3) to close off the small road which accesses the area.

Three 0.3-acre (0.12-ha) patch cuts were laid out in portions of the timbered stand which most closely approximated the elevation and water table of the adjoining component. The units were logged in the winter of 1983-84 and now await site

preparation. One unit is scheduled for mechanical scarification; and the other two will be broadcast burned. One-half of the scarified unit and one of the burned units will be seeded with umbels. The forested edges of units to be seeded will be broadcast with Osmorhiza occidentalis (commercial seed); the remainder of these units will be seeded with Heracleum and Angelica (collected on site). Differences in seeding location by species are based on the apparent preference of Osmorhiza for a light overstory canopy. Seed collection will occur in fall when seeds are plump and completely dry. Seeding will also occur in fall, before snowfall, and at an application rate of about 6 lb/acre (6.7 kg/ha). A permanent transect containing a series of 10.8 ft^2 plots (1 m^2) located 6.5 ft (2 m) apart, center to center, will be placed to monitor each of the four treatments (burned-seeded, burned-unseeded, scarified-seeded, and scarified-unseeded).

One crew day (3 person-days) is required for seed collection and one crew day for broadcasting. Four days were programmed for project reconnaissance and monitoring. Funding has been appropriated from Sale Area Improvement Funds (Knutson-Vandenburg [K-V]). The total project cost is estimated to be about $800. Human access will be controlled with a tank trap, which will be placed by the timber sale purchaser under a contractual agreement.

In another area (Gordon Creek), an umbel-seeding project has been recently completed. The drainage is similar to Ross Creek in habitat type, elevation, aspect, and water table but differs in its general paucity of spring bear foods and complete absence of an umbel seed source. Two riparian units of 7 acres (2.8 ha) were placed more than 0.5 mi (0.9 km) off a closed road. The units were logged and mechanically scarified in 1983. Slash piles were burned in fall of 1984, and a total of 0.5 acres (0.2 ha) of streamside area within the units was seeded in spring of 1985 with Heracleum and Angelica (collected from the Ross Creek site). Seed was broadcast at a rate of 6 lb/acre (6.7 kg/ha). These units will be monitored similarly to those at Ross Creek to determine project effectiveness.

A crew of three collected seed for 4 hours, and seeding was accomplished by volunteers. The total project cost of $300 included 2 days of monitoring.

Poorman Creek spring range project.--The Poorman Creek project site was also a densely forested hemlock/beadlily habitat type on flat terrain at about 3,000 ft (914 m) elevation. The area coincides with prime grizzly bear habitat but lacks the well-developed riparian vegetation characteristic of the Ross Creek site, and is completely devoid of bear foods. The objective of this project is to create spring range components through placement of three 1-acre (0.41-ha) clearcuts. The units were logged and the sites prepared in the summer of 1981. Slash was mechanically piled, effecting 40 to 50 percent ground scarification.

Permanent transects containing twenty 10.8 ft^2 (1 m^2) plots will be placed in each unit and read this summer. Monitoring to date has consisted of visual walk-throughs and placement of photopoints. Three years following project completion, the sites have approximately 100 percent herbaceous cover, composed predominantly of spring bear forages such as sedges, grasses, umbels, thistles (Circium sp.), and a variety of forbs. The benefit of increasing feeding site availability is compounded by site proximity to cover and by the lack of human access. This project did not require K-V or other wildlife dollars.

BURNING

Fire can also be an effective tool for directly improving habitat (Martin 1979; Zager 1980) but project objectives must be clearly defined and conveyed to the fire manager. Of particular concern are fuel loading and continuity, soil moisture, timing, and vegetative phenology.

Approximately 3,500 acres (1,416 ha) of wildlife habitat are prescription burned annually on the Kootenai National Forest. The emphasis of these projects is primarily to improve the quality of ungulate winter ranges. Following are two examples of burns which focus more heavily on promoting forage opportunities for grizzlies. Neither of these projects has been quantitatively monitored to determine changes in bear food diversity or abundance.

A series of at least twenty 43.2 ft^2 (4 m^2) circular plots may be adequate for sampling the relative abundance of emerging shrubs (Peek 1984). Plots should be about 20 ft (6 m) apart and be placed along a linear transect running diagonally across the slope. Each plot can contain a 10.8 ft^2 (1 m^2) circular subplot to describe the percent ground cover of specific forbs and graminoids. This sampling design can also be used to generate production data.

Grizzly Peak burn.--About 75 acres (30 ha) of a high-elevation (5,200 to 6,000 feet, 1,585 to 1,829 m) south-facing slope were scheduled for fall ignition. The site consists mostly of convex graminoid and beargrass (Xerophyllum tenax) sidehill parks, with a small portion of the area (less than 2 percent) in globe huckleberry (Vaccinium globulare) microsites. The habitat type is subalpine fir/beargrass with scree inclusions.

Although the area is used by bears in fall, when berries from huckleberry (Vaccinium spp.) and serviceberry (Amelanchier alnifolia) become available, heaviest bear use occurs in late spring and early summer, on forbs and graminoids (bunchgrasses [Agropyron spicatum, Festuca spp.], and Carex geyeri). The project objective is to stimulate spring forage production. The area was burned in the fall because of the brief opportunity to burn in the spring at that elevation (immediate green-up generally follows snow recession).

The area was burned by hand in October 1981 after the vegetation had been cured out by heavy fall frost. Fire carried evenly on grassy sidehills but failed to generate sufficient heat to affect the moister microsites. Walk-through surveys indicate an excellent response by graminoids, a reduction in junipers (Juniperus sp.), and little or no change in the condition or abundance of beargrass or huckleberry.

A crew of 15 was required to conduct the burn. Total project cost was about $700 ($9.33/acre, $23/ha).

Bobcat Draw burn.--The project site is a 70-acre (28-ha) shrubfield, heavily interspersed with grasses. Predominant vegetation includes serviceberry, ceanothus (Ceanothus velutinus and C. sanguineus), willow (Salix spp.), huckleberry, pinegrass (Calamagrostis rubescens), and several bunchgrasses and forbs. The area is rapidly becoming encroached upon by Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta). At an elevation of 5,000 ft (1,524 m), the site is south-facing and is designated as a Douglas-fir/pinegrass habitat type. Wildlife values are primarily spring bear range and ungulate summer range. Bear foods are mostly graminoids, with a small number of berries available in the fall. Project objectives are to eradicate the encroaching conifers while invigorating the graminoids and shrubs. Burning was scheduled for spring to reduce the risk of catastrophic loss.

A helicopter drip torch was used to burn the area in May 1980. Cursory surveys suggest that objectives were met. Virtually all conifers within the burn area were destroyed. Graminoids and most shrubs (ceanothus, willow, serviceberry, and rose [Rosa sp.]) appear to have responded extremely well, whereas huckleberry, possibly affected by high temperatures, has only recently re-emerged.

Seven people assisted in the helicopter operation, which required about 1 hour. Total project costs amounted to about $300 ($4.30/acre, $10.63/ha).

SEEDING GRAMINOIDS AND LEGUMES

Spring use of graminoids and legumes by bears is well-documented in the literature (Husby and McMurray 1978; Mealey and Jonkel 1975; Mealey and others 1977; Zager 1980). Seeding disturbed areas such as roadbeds, cutbanks, landfills, and timber harvest units is an excellent method of accelerating vegetative recovery and can substantially increase spring bear food quality and abundance. Currently, about 400 acres (162 ha) of the Kootenai National Forest (mostly roads) are seeded with legumes and graminoids each year. Of this, about 10 percent is accomplished specifically with grizzly bear habitat improvement in mind. The opportunities for roadbed seeding are expected to increase as the open road density within identified grizzly bear habitat decreases (as directed in the draft Kootenai Integrated Forest Plan). The significance of this is that for every mile of forest road in place, about 2 acres (0.81 ha) of valuable edge habitat remain out of production. During natural succession, closed roads are slowly invaded, generally with less desirable species such as alder (Alnus spp.). Seeding legumes and grasses is a method of returning these road surfaces to more productive habitat.

Various site-specific factors such as temperature and moisture gradients, soil compaction, and level of human disturbance should be evaluated before a seeding project is undertaken. Seed mixes can be custom designed to suit environmental conditions and should contain a high proportion (greater than or equal to 50 percent) of legumes because they are desirable bear foods (Nagy and Russell 1978; Pearson 1975) and are versatile and hardy (Vallentine 1971). Indigenous grasses and legumes should be included in mixes when available and affordable.

Application rates may vary, depending on germination rates and seed sizes. A typical mild zone mix suitable for bear forage seeding in a hemlock/beadlily habitat type might be applied at a rate of 24 lb/acre (26.9 kg/ha), broken down as follows: white dutch clover (Trifolium repens) 25 percent; alsike clover (Trifolium hybridum) 25 percent; birdsfoot trefoil (Lotus corniculatus) 12.5 percent; smooth brome (Bromus inermis) 12.5 percent; timothy grass (Phleum pratense) 12.5 percent; and orchardgrass (Dactylis glomerata) 12.5 percent. Though more expensive, pure live seed (PLS) increases germination confidence and is therefore recommended.

A good standard commercial fertilizer such as 27-10-5 (N-P-K), applied at a rate of about 200 lb/acre (224 kg/ha), can be helpful in successfully establishing forage seedlings; but this advantage can be short lived if soils are nutrient deficient. Use of a high proportion of legumes can be especially desirable on poor soils because of their ability to fix nitrogen (Vallentine 1971).

Seeding and fertilization costs vary with mix composition, type of fertilizer, and application rate but range typically from $75 to $100/acre ($185 to $247/ha). One person can seed 1 to 2 acres (0.4 to 0.81 ha)/day depending on topography and access. Seeding and fertilization projects in northwestern Montana should be scheduled for spring or fall (Kuennen 1979).

Scarification may be indicated if soils are severely compacted. Heavy machinery, such as a D-7 caterpillar, is best suited for ripping soils to a minimum depth of 12 inches (31 cm). Scarification rates average about 5 acres (2 ha)/hour at a cost of about $50/acre ($124/ha).

When human disturbance could significantly alter the habitat effectiveness of an area or the security of bears using an area, forage seeding should not be considered. In such instances, if

seeding is required to meet other resource objectives, less palatable species such as western wheatgrass (Agropyron smithii), streambank wheatgrass (A. riparium), crested wheatgrass (A. desertorium), perennial ryegrass (Lolium perenne), or any of the coarser oatgrasses (Danthonia spp.) should be used (Jonkel 1985). Fertilization in these situations should be forgone. In all roadbed seeding projects, application of the preferred forage seed mix should be deferred in the first 0.25 to 0.5 mi (0.4 to 0.8 km) above the road closure to insulate the project area from human disturbances.

PLANTING BERRY-PRODUCING SHRUBS

Mixed shrubfield-cutting units are critical late summer-fall foraging components in the Cabinet-Yaak Grizzly Bear Ecosystem (Christensen and Madel 1982). Clearcut areas of suitable habitat types which are not excessively disturbed are conducive to the establishment of important berry-producing shrubs such as huckleberry (V. globulare and V. scopulina) and mountain ash (Sorbus scopulina) (Zager 1980). Conversely, cutting units which are severely impacted by scarification and intense heat will have low densities of these species (Arno 1979; Martin 1979; Zager 1980) and may never become valuable bear habitat components. The objective of the following project is to artificially re-establish berry-producing shrubs in a heavily scarified cutting unit.

Purdy Ridge planting project.--The project area occurs in prime grizzly bear habitat and is characterized as a hemlock/beadlily-subalpine fir/beadlily ecotone with moderate to heavy densities of V. globulare and V. scoparium. At about 4,500 ft (1,372 m) in elevation, the site faces east and consists of 20 acres (8.1 ha) of a 50-acre (20-ha) "bug-killed" stand currently being tractor logged and tractor piled. Scarification is expected to be severe.

The project consists of planting 1,150 stems each of V. globulare and S. scopulina seedlings at a total stocking density of 109 stems/acre (270 stems/ha) or a 20- by 20-ft (6.1- by 6.1-m) spacing. The specific objective is to establish a pioneer population from which the unit can be restocked.

About 0.5 lb (0.23 kg) of ripe Vaccinium fruits will be collected this fall from adjacent stands and shipped to a commercial nursery for germination and rooting in tube packs. Eight- to 12-inch Sorbus seedlings will be purchased from commercial nursery stock. Planting is scheduled for spring of 1987. The access road will be closed contractually 1.5 mi (2.4 km) from the site and seeded. Transects containing 50 marked individuals of each species will be surveyed annually to determine percent survival. Additionally, standard 0.1-acre (0.04-ha) plots will be placed within the planted and unplanted (control) portions of the unit to generate information on shrub densities and community structure.

Seed collection and planting will require about 11 person-days (at a planting rate of 2 acres [0.81 ha]/person/day). Total project costs (funded through K-V) including planting stock ($0.65/stem) and 4 days of monitoring are expected to be $2,600 or $130/acre ($320/ha). The 2 acres (0.81 ha) of road seeding will cost about $150.

CONCLUSIONS

The merits of direct habitat improvement projects such as those described can be challenged on the basis of their undetermined biological or cost effectiveness. Other factors, however, appear to be certain: the amount of effective high quality grizzly bear habitat will continue to decrease as private land development, road construction, minerals exploration and development, recreational pressure, and more intensive timber management increase.

Opportunities to stem the cumulative impacts from these activities must be taken on all fronts, whenever possible. This is particularly critical at a time when funding levels, which have historically been inadequate, continue to decline. Sale Area Improvement Funds (K-V), although not a panacea, still provide the best opportunity to finance projects. Sale areas proposed in grizzly bear habitat, particularly in habitat allocated to meet grizzly bear management objectives, should be carefully assessed for K-V project potential.

Research is needed to validate the effectiveness of different treatments but forest management must go on in the interim. Wildlife biologists involved in forest management cannot wait for conclusive evidence. Project opportunities are either aggressively sought out or they are lost. Professional judgment and available information must suffice; biologists can use verified habitat improvement techniques on a large scale (for example, burning) and creatively seek new projects to try on a smaller scale.

Biologists need to design practical but inexpensive methods of monitoring the effectiveness of their projects--not to take the place of research but to allow them to evaluate their efforts more objectively. The research and academic communities need to acknowledge the potential of proactive habitat manipulation and to direct more applied research toward developing appropriate procedures.

REFERENCES

Arno, Stephen F. Classification of seral communities of major forest habitat types in western Montana. Annual Progress Report INT-1205-587. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979. 32 p.

Christensen, Alan G.; Madel, Michael J. Cumulative effects analysis process - grizzly habitat component mapping. 1982. Unpublished report on file at: Kootenai National Forest, Forest Service, U.S. Department of Agriculture, Libby, MT.

Husby, P.; McMurray, N. Seasonal food habits of grizzly bears (*Ursus arctos horribilis* Ord) in northwestern Montana. In: Border Grizzly Project Annual Report No. 3. Missoula, MT: University of Montana, School of Forestry; 1978: 109-134.

Jonkel, C. Personal communication. Missoula, MT: University of Montana, School of Forestry; 1985 April 12.

Kuennen, Louis J. Seeding to control erosion in the Kootenai National Forest. 1979. Unpublished report on file at: Kootenai National Forest, Forest Service, U.S. Department of Agriculture, Libby, MT.

Mace, Richard D.; Jonkel, Charles J. Seasonal food habits of grizzly bears (*Ursus arctos horribilis* Ord) in northwestern Montana. Border Grizzly Project Annual Report No. 5. Missoula, MT: University of Montana, School of Forestry; 1980: 46-49.

Martin, Patsy. Productivity and taxonomy of the *Vaccinium globulare*, *V. membranaceum* complex in western Montana. Missoula, MT: University of Montana; 1979. 136 p. M.S. thesis.

Mealey, Stephen P.; Jonkel, Charles J.; Demarchi, Ray. Habitat criteria for grizzly management. In: Peterle, Tony, ed. 13th congress of game biologists: proceedings; 1977 [date of conference unknown]; Atlanta, GA: 13th Congress of Game Biologists; 1977: 276-289.

Mealey, Stephen P.; Jonkel, Charles J. Grizzly bear food habits and use. Border Grizzly Project Special Report No. 1. Missoula, MT: University of Montana, School of Forestry; 1975. 4 p.

Nagy, John; Russell, R. Ecological studies of the boreal forest grizzly bear (*Ursus arctos*). Annual Report for 1977. Edmonton. Canadian Wildlife Service; 1978. 72 p.

Pearson, A. The northern interior grizzly bear *Ursus arctos* L. Report No. 34. The Queens Printers, Montreal. Canadian Wildlife Service; 1975. 86 p.

Peek, J. Personal communication. Moscow, ID: University of Idaho, College of Forestry, Wildlife and Range Sciences; 1984 October 15.

Pfister, Robert D.; Kovalchik, Bernard L.; Arno, Stephen F.; Presby, Richard C. Forest habitat types of Montana. General Technical Report INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Vallentine, John F. Range development and improvements. Provo, UT; Brigham Young University Press; 1971. 516 p.

Zager, Pete E. Influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Missoula, MT: University of Montana; 1980. 131 p. Ph.D dissertation.

GRIZZLY HABITAT IMPROVEMENT PROJECTS ON THE SOUTH AND MIDDLE FORK FLATHEAD RIVER

Thomas M. Holland

ABSTRACT: The South and Middle Forks of the Flathead River contain areas of prime grizzly bear (Ursus arctos horribilis) habitat. Between 1978 and 1984, the Spotted Bear and Hungry Horse Ranger Districts conducted habitat improvement projects designed to benefit the grizzly bear and other wildlife species. These improvement projects include prescribed burning, clover seeding, plantings, openings, and road closure programs. The helitorch has proven to be the most effective method for prescribed burning, and the cost has been approximately $15 to $20 per acre. First growing season regrowth response has been as much as 60 inches for some browse species such as willow, which is an important big game food in this area. Maintenance of large big game herds is important to the grizzly bear because they ensure a continued source of carrion. Clover seeding costs about $6 per acre, and effectively provides early season bear foods. An intensive road closure program has been implemented, and on one timber sale area the open road density was reduced 50 percent as a result of the sale.

INTRODUCTION

The South and Middle Forks of the Flathead River lie within prime occupied grizzly bear habitat in the middle of the northern Continental Divide Grizzly Bear ecosystem, which contains an estimated 440 to 680 grizzly bears (U.S. Department of Interior, Fish and Wildlife Service 1982). The Flathead National Forest staff estimates that approximately 150 to 180 grizzly bears live on Flathead National Forest lands within the area drained by the three forks of the Flathead River (U.S. Department of Agriculture, Forest Service 1983). The South Fork of the Flathead drains an area of approximately 1,663 mi^2, and is administered entirely by the Spotted Bear and Hungry Horse Ranger Districts. No private land exists within the entire drainage. The Middle Fork of the Flathead drains an area of approximately 1,128 mi^2, and is generally administered by the Flathead National Forest south of U.S. Highway 2 and by Glacier National Park north of U.S. Highway 2. Scattered low-elevation private inholdings occur throughout the length of this river valley.

The area outside designated wilderness, particularly within the South Fork, is under intensive timber management with approximately 25 to 30 million board feet of timber harvested annually. The area was first roaded in the mid 1950's and during the 1960's and 1970's the area was subject to widespread logging and roading.

Grizzly bear densities are estimated to be high in some areas of the South and Middle Fork drainages. Within one study area, consisting of 128 mi^2 in the South Fork, there was an autumn density estimate of one grizzly bear per 9.8 miles (Mace 1980).

GRIZZLY BEAR HABITAT IMPROVEMENT PROJECTS

Habitat management techniques that simulate habitat components known to be important to the grizzly bear have the potential to improve habitat. These projects are funded by Forest Service wildlife funds and K-V dollars which are collected from the sale of National Forest timber.

Little, if any, information has been reported or published about improving habitat for the grizzly bear, however, the Spotted Bear and Hungry Horse Ranger Districts have been successfully experimenting with a number of techniques. These include prescribed burning, clover seeding, aspen planting, browse planting, lodgepole pine conversions, and road management. The following list shows the projects and the acres treated since 1978:

Habitat improvement	Acres treated
Clover seeding	1,418
Prescribed burning	1,230
Lodgepole pine conversions	280
Aspen/browse planting	200

Natural fires, under prescription, within the Bob Marshall and Great Bear Wilderness areas will be allowed to burn and, in addition, create vegetative mosaics which will directly benefit the grizzly bear. The projects also emphasize logging practices such as broadcast burning, which have been shown to minimize damage to the root systems of key bear foods.

PRESCRIBED BURNING

Winter ranges within the South and Middle Forks of the Flathead provide winter forage for most of the Flathead National Forest's elk (Cervus elaphus) herd, which numbers over 4,000 animals. In addition, mule deer (Odocoileus hemionus), white-tailed deer (Odocoileus virginianus), moose (Alces alces), and mountain goat (Oreamnos americanus) winter on these ranges. Maintenance and improvement of these winter ranges for big game should

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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continue to benefit the grizzly bear because their dependency upon carrion in spring following den emergence has been well documented. Mealey (1977) found in Yellowstone that during the early spring season grizzlies are primarily meat-eaters. They congregate on ungulate winter ranges and eat available animal material. Studies done in Northwest Montana and the South Fork of the Flathead also substantiate this preference for carrion. Mace (1984) noted the importance of ungulate winter ranges and valley bottoms, which grizzly bears travel regularly in spring when searching for carrion. Jonkel and others (1980) speculate that this food source may be particularly important to vulnerable subadult bears. In addition to carrion, weakened or otherwise vulnerable animals are occasionally taken by grizzlies. Big game carrion, particularly elk and mule deer, are an important nutrition source for grizzlies in the South and Middle Forks in the spring, as evidenced by the use of carcasses from late April to early June (Holland 1985). Mealey (1977) feels that the pregrowing season in Yellowstone is the only time when the bears' supply of protein may be strictly limited. He speculated that this period is likely to be the primary one in which natural grizzly bear population regulation occurs.

Winter range areas also contain a number of fruit-producing shrubs that provide important summer and early fall foods for the grizzly bears. Among the most important foods in the area are blue (globe) huckleberry (Vaccinium globulare), serviceberry (Amelanchier alnifolia), buffaloberry (Shepherdia canadensis), chokecherry (Prunus virginiana), mountain ash (Sorbus scopulina), and dogwood (Cornus stolonifera). Probably the most important fruit-producing shrub on these winter ranges is serviceberry. Grizzlies have been observed feeding on serviceberry fruits in late summer (Holland 1985).

The objective of prescribed burning is to immediately rejuvenate browse species important to big game and grizzly bear and to prevent coniferous tree seedlings from invading brush fields. Between 1978 and 1984, the Spotted Bear and Hungry Horse Ranger Districts conducted prescribed burning on over 1,230 acres of the South Fork big game ranges, on which grizzlies also depend. Spring burning is a common and accepted practice to rejuvenate seral shrubfields and is less expensive than fall burning because minimal control measures are necessary. Spring burns have been performed between early March and mid-May, depending on elevation and weather conditions, because the best burning conditions occur then. Burns conducted in May are less effective because green vegetation inhibits fire spread. One fall burn was conducted but was not as effective as the spring burns because fuels in the lower elevation burn areas had not adequately cured. Most fires are started with a helicopter drip torch; however, a few are ignited by hand. The helitorch method has proven to be the most effective method because of steepness of slope and inaccessibility. Burns averaged over 200 acres per year and cost between $15 and $20 per acre. In 1985 four burns, totalling approximately 350 acres, are scheduled on the two Districts.

Vegetation burned on Horse Ridge on April 16, 1984, was measured again on August 16, 1984, to determine the average height of resprouting 4 months after burning. Fire totally removed the above-ground portion of the plants and as much as 60 inches of regrowth was recorded on some species. The following list shows the average species response to fire on the Horse Ridge Burn of 1984:

Browse species	Average height of regrowth August 16, 1984
	Inches
Amelanchier alnifolia (serviceberry)	28.5
Acer glabrum (mountain maple)	36.25
Betula papyrifera (paper birch)	40.0
Ceanothus sanguineus (redstem ceanothus)	31.75
Ceanothus velutinus (evergreen ceanothus)	17.0
Populus tremuloides (quaking aspen)	33.5
Prunus virginiana (chokecherry)	33.0
Salix spp. (willow)	55.5

WILDERNESS PRESCRIPTION BURNS

Fire suppression for the past 60 years has changed the vegetative mosaic within the Bob Marshall ecosystem and has substantially reduced the quantity of early successful stages of vegetation. Effective fire suppression since 1920 has therefore negatively affected grizzly bear habitat and food production on mesic sites in northwestern Montana. As conifers encroach and the vegetation community develops in vast areas of seral, shrub-dominated plant communities created from wildfires, production and canopy cover of certain bear food plants may decline. According to Zager (1983) this eventually produces old-growth forests with closed canopies where bear food production is relatively low.

Natural wilderness prescription fires and planned ignition, which may be approved in the near future, will help reverse the loss of seral-dominated brushfields, where globe huckleberry is common. In areas where fire or other disturbances have been absent, huckleberries are gradually crowded out by invading trees or other vegetation (Minore 1972).

Huckleberries are a major component of grizzly bear diets on the Flathead National Forest from late July through September. Martin (1980) found that the most productive huckleberry sites were

located on mesic north or east aspects, which were burned by wildfire 25 to 60 years ago, or on 8- to 15-year-old clearcuts that were broadcast burned to reduce slash. Therefore, long-range planning is necessary to assure the continued production of globe huckleberry fruit crops on grizzly bear habitat.

In June 1983 a wilderness fire plan was approved for the Bob Marshall and Great Bear Wildernesses. This plan would allow fires that meet specific criteria to burn without human interference. In 1984, the first full year of implementation of the plan, eight fires were allowed to burn; however, only three of the eight exceeded spot size and together totaled 165 acres.

CLOVER SEEDING

Trifolium (clover) and other herbaceous vegetation were among preferred plant foods and constituted a high proportion of the plant food consumed by grizzlies within a study area in the Scapegoat Wilderness of Montana (Craighead and others 1982). Mealey (1977) found that in the Yellowstone area, succulent new grass is the earliest and most important food eaten by grizzlies in the spring after they emerge from dens. He found that white clover was extensively used where it was abundant and associated with other bear foods.

Since 1980, just over 1,400 acres of disturbed logging sites such as landings, skid trails, and obliterated roads have been seeded with clover within the South Fork of the Flathead River. Although clover is a favorite grizzly food from early May to early July, seeding occurred only behind road closures to minimize encounters between feeding bears and humans--encounters that often result in the death of a grizzly. Clover seeding generally costs about $6 per acre when seeding at a rate of 3 pounds per acre.

ASPEN AND BROWSE PLANTINGS

Aspen and browse have been planted on approximately 200 acres of disturbed logging sites. Aspen, black cottonwood, and other fast-growing deciduous species are planted around springs and wet sites to provide cover that grows quickly. These moist sites have been recognized as important microsites for the grizzly bear. These species also provide diversity in the sometimes monotypic coniferous forest regeneration found on logged sites. Serviceberry and chokecherry have also been planted on suitable sites within sale areas frequented by grizzlies. Aspen and browse seedlings are planted for approximately $25 per acre. The cost of the seedlings comprises the majority of this cost because they are planted by volunteers.

LODGEPOLE PINE CONVERSIONS

Portions of the South and Middle Forks of the Flathead contain extremely dense stands of lodgepole pine that are a result of the intense wildfires of the early 1900's. These stands are stagnated, have a high number of stems per acre, and contain little or no understory vegetation. In 1978 a few small patches of this timber type were slashed and burned so that browse and grass would invade the openings and provide supplemental forage for wildlife.

Since 1980 approximately 130 acres of stagnated lodgepole pine in the South Fork and 150 acres in the Middle Fork drainages have been sold for posts and poles or piled and burned directly when no market existed. These areas are then replanted with a mixture of tree species, including some hardwoods. This treatment increases timber potential of the site while providing for wildlife diversity. This treatment can be expensive if the wood products cannot be sold.

ROAD CLOSURES

Timber harvest and roading increased greatly about 1960 in the South and Middle Forks of the Flathead River. Most of these roads remained open until the mid-1970's and early 1980's, when a concerted effort was made to reduce the number of open roads to protect wildlife, particularly the grizzly bear. The negative effect of open roads on elk and grizzlies is well documented (Lyon and others 1985; Mace 1984).

Information collected by Zager (1980) from four radio-collared grizzly bears in northwestern Montana indicates that grizzlies generally avoid areas where trees have been harvested and where roads are open to motorized use. Bear use in these areas is restricted to certain areas along secondary roads or where roads have been closed.

In a study on the west side of Hungry Horse Reservoir, Jonkel and others (1980) found that two of the 10 South Fork Flathead grizzlies marked during the 1975 to 1978 study were subsequently illegally killed.

In 1983 three female grizzly bears were illegally killed on the east side of Hungry Horse Reservoir. This occurred in two separate, unrelated incidents only 1 day apart. Two of the three grizzlies were adult females with cubs; the other was a female cub. These incidents occurred during the spring black bear hunting season. These statistics support the view that many grizzlies are illegally killed in the South Fork of the Flathead. This may occur because a relatively high number of grizzlies inhabit low-elevation roaded areas in the spring, which makes them likely targets for accidental killings by black bear hunters or intentional shooting by poachers.

As a result of these illegal kills, the Spotted Bear and Hungry Horse Ranger Districts have intensified their efforts to reduce the number of miles of open roads in prime grizzly bear habitat, thus providing secure habitat for the bear and greatly reducing the risk of illegal kills. Roads are either seasonally closed during critical time periods or are permanently closed. For example, in 1984, 10 gates were installed which seasonally or permanently closed a total of 58 miles of road.

Since 1982, approximately 200 miles of road have been seasonally or permanently closed to vehicle use. This is in addition to other roads which are closed in conjunction with individual timber sales. With each new timber sale proposal a transportation plan is developed for that area, usually by a major drainage, to determine what roads will be kept open. Dollars generated through these timber sales are used to close the roads by means of a gate, physical barrier, or cement structures called New Jersey guardrails.

An example of how a timber sale can improve habitat for grizzly bears and other wildlife occurred when the Hungry Horse Ranger District sold an 11 million board foot sale in 1984 in the Middle Fork Drainage. Before this sale, a total of 38 miles of roads (30 open, eight closed) accessed the area. The 8 miles of new road construction necessary to access new logging units increased the total to 46. Gates and road closures were put in place even before actual logging began. Of the 46 miles of road, 28 were then permanently closed, leaving only 18 miles of open access roads, a net loss of 12 miles from what existed before the sale. Figure 1 compares the amount of open road before and after the sale. Most of the 18 miles left open is the main arterial road traversing the area. Road closures thus reduced the open road density from approximately 1 mile of road per square mile before the sale to 1/2 mile of road after the sale. Gates on roads used to haul logs were purchased and installed by the timber sale purchaser. Without timber sale activities to generate dollars to close these roads, many would remain open until other funding sources were made available. Currently 112 structures exist in the zone and effectively close over 400 miles of road.

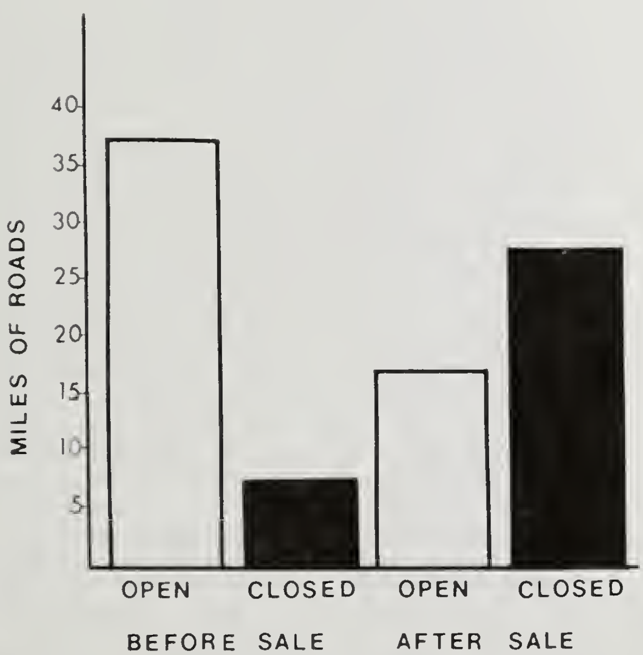

Figure 1.--Miles of open and closed roads before and after the Middle Fork lodgepole sale.

CONCLUSIONS

Based on our knowledge of grizzly bear food preference and their need for isolation from humans, we can assume that our grizzly bear habitat improvement program is a positive step to enhance and protect grizzly bear habitat. We still need to develop well-planned and documented long-range studies to evaluate these efforts. This information will provide evidence of the benefits derived from these improvement projects.

REFERENCES

Craighead, John J; Sumner, J.S.; Scaggs, G.B. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Wildlife Wildlands Institute Monograph No. 1. Missoula, MT: University of Montana; 1982. 279 p.

Holland, Thomas M. [Personal observations]. Hungry Horse, MT: U.S. Department of Agriculture, Forest Service, Flathead National Forest; 1985.

Jonkel, C.; Lee, L.; Thier, T.; McMurray, N.; Mace, R. Sullivan Creek grizzlies. Border Grizzly Project Special Report No. 23. Missoula, MT: University of Montana; 1980. 9 p.

Lyon, L. Jack; Lonner, Terry N.; Jones, Jack. [and others]. Coordinating elk and timber management; final report of the Montana cooperative elk-logging study. Bozeman, MT: Montana Department of Fish, Wildlife and Parks; 1985. 53 p.

Mace, Richard D.; Jonkel, C. Grizzly bear reponse to habitat disturbance. Border Grizzly Project Annual Report No. 5. Missoula, MT: University of Montana, 1980: 70-98.

Mace, Richard D. Identification and evaluation of grizzly bear habitat in the Bob Marshall Wilderness Area, Montana. Missoula, MT: University of Montana; 1984. 176 p. M.S. thesis.

Mace, Richard D.; Jonkel, C. The effects of a logging activity on grizzly bear movements. In: The Predator Symposium; 1984 March; Missoula, MT. Missoula, MT: University of Montana; [in press].

Martin, Patrica. Wildlife and logging influences on the globe huckleberry in Northwestern Montana. Madison, WI: In: Proceedings International Conference on Bear Research and Management. 5: 159-165; 1980.

Mealey, Stephan P. The natural food habits of grizzly bears in Yellowstone National Park, 1973-74. Kalispell, MT: In: Proceedings International Conference on Bear Research and Management. 4: 281-292; 1977.

Minore, Don. The wild huckleberries of Oregon and Washington--a dwindling resource. Research Paper PNW-143. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1972. 17 p.

U.S. Department of Agriculture, Forest Service. Flathead National Forest. Draft environmental impact statement. Kalispell, MT; 1983: III-25 p.

U.S. Department of Interior, Fish and Wildlife Service. Grizzly Bear Recovery Plan. Denver, CO; 1982. 195 p.

Zager, Peter; Jonkel, Charles; Habeck, James. Logging and wildfire influence on grizzly bear habitat in northwestern Montana. Madison, WI: In: International Conference on Bear Research and Management. 5:124-132; 1980.

Zager, Peter E.; Jonkel, Charles J. Managing grizzly bear habitat in the northern Rocky Mountains. Journal of Forestry. 81(8): 524-526; 1983.

COORDINATING LIVESTOCK AND TIMBER MANAGEMENT WITH THE GRIZZLY

BEAR IN SITUATION 1 HABITAT, TARGHEE NATIONAL FOREST

Mark L. Orme and Robert G. Williams

ABSTRACT: Adjustments were made in the timber and livestock management programs to accommodate the needs of the grizzly bear in Situation 1 habitat. Some of the major adjustments in the timber management program include reducing cutting unit size; using silvicultural prescriptions to benefit understory forage plants; increasing the size of leave strips; road closures; cover objectives that would not decline below 50 percent; and maintaining security areas of at least 5,000 acres. Some of the major adjustments in the livestock management program include closing four sheep allotments; converting one sheep allotment to a cattle allotment; full-time monitoring of all sheep allotments; restricting methods of handling bear predation problems; and removing sheep from an allotment in cases of conflict.

INTRODUCTION

One of the longest historical uses of the Targhee National Forest has been domestic livestock grazing; in some areas, grazing predated the creation of the National Forest. When the grizzly bear (*Ursus arctos*) was classified as a threatened species, historical grazing uses and public attitudes were in conflict with the immediate needs of the bear. Intensive timber management on the Targhee has been a more recent event, beginning mainly in the 1960's. Approximately half of the timber base on the Targhee is lodgepole pine (*Pinus contorta*), and about 90 percent of the pine was mature. The mountain pine beetle (*Dendroctonus ponderosae*) began killing large numbers of trees in the late 1960's and 1970's. The Forest subsequently began a salvage program, which in some cases was in conflict with the needs of the bear. This paper presents an overview of grizzly-livestock-timber coordination that has occurred on the Targhee National Forest since 1975, when the bear was officially listed as a threatened species under the Threatened and Endangered Species Act. It describes changes in livestock grazing and timber management, along with formal consultations that have occurred with the U.S. Department of the Interior, Fish and Wildlife Service.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30 - May 2, 1985.

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LOCATION

Grizzly bear Situation 1 habitat is located in two areas of the Targhee National Forest (fig. 1). One area lies in the northeast corner of the Forest and occupies 35,960 acres. This area includes the Henry's Lake Mountains north and east of Henry's Lake. The boundary follows the Continental Divide, which is also the Idaho-Montana state line. The area is characterized by high glaciated mountains rising to 10,000 ft elevation. Vegetation varies from heavy lodgepole pine and Douglas-fir (*Pseudotsuga menziesii*) timber stands in the lower elevations to subalpine and alpine vegetation in the middle and upper elevations. Perennial streams and springs occur throughout the area. Domestic livestock grazing has been the predominant resource use; timber harvest has been limited; and recreation use is considered light during the summer, with increasing use during the fall hunting season and high use during the winter snowmobile season.

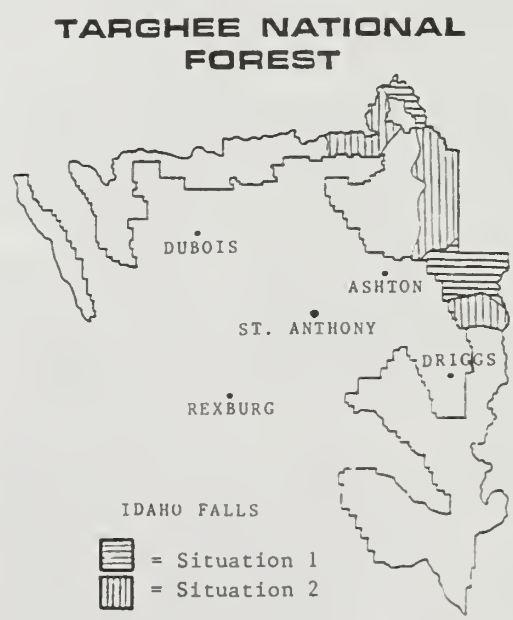

Figure 1.--Situation 1 and 2 grizzly bear habitat.

The second area lies along the southern boundary of Yellowstone National Park and occupies 138,140 acres. Elevations range from 5,600 ft on the western edge to 9,200 ft on the eastern side. The western portion of this area is

characterized by large lodgepole pine uplands and plateaus, dissected by gorgelike canyons. Shallow lakes and marshes are scattered throughout the area. The principal timber type is lodgepole pine; however, Douglas-fir grows along the canyon ridges and north facing canyon slopes. The lodgepole pine stands have undergone severe attack from the mountain pine beetle, and large areas have been salvaged. Cattle and sheep grazing occur within the area.

This second area includes the newly created Winegar Hole Wilderness adjacent to the southern boundary of Yellowstone National Park. Numerous ponds, seeps, meadows, shallow lakes, and streams are dispersed throughout the area. These aquatic and riparian habitats are surrounded by extensive stands of lodgepole pine, aspen (Populus tremuloides), Douglas-fir, and subalpine fir (Abies lasiocarpa). The dominant human use is for recreation.

The eastern portion of this second area is part of the newly created Jedediah Smith Wilderness. The area is characterized by high-elevation, glacially scoured ridges and basins perched above U-shaped canyons. Scattered patches of subalpine fir, spruce (Picea engelmannii), Douglas-fir, and whitebark pine (Pinus albicaulis) are interspersed through natural forb and grass meadows. The dominant human use is recreation and livestock grazing.

RECENT GRIZZLY BEAR USE

Forest personnel have annually compiled a list of grizzly bear sightings. Figure 2 summarizes the sightings from 1965 through 1984.

Documentation of grizzly bear-livestock-human interactions on the Targhee National Forest has been accomplished through several research studies and agency reports (Jorgensen and Allen 1975; Jorgensen 1979, 1983; Griffel 1981; Knight and Judd 1983; U.S. Department of Agriculture, Forest Service 1981-1984). These studies and reports document consistent human-bear-sheep interactions and incidents. These studies and reports have shown only an occasional interaction between cattle and grizzly bears, with no human-bear incidents occurring as a result of cattle grazing.

No studies have analyzed the effects of logging on grizzly bears on the Targhee National Forest. However, Interagency Grizzly Bear Study Team research has identified grizzly bear-habitat relationships in the Yellowstone area (Blanchard 1983). Interagency Guidelines have been developed for coordinating timber management with grizzly bear needs. (USDA, Forest Service 1979, 1982). Verified grizzly bear sightings have occurred in timber sale areas before, during, and following harvest activities. No verified human-bear incidents have been associated with logging.

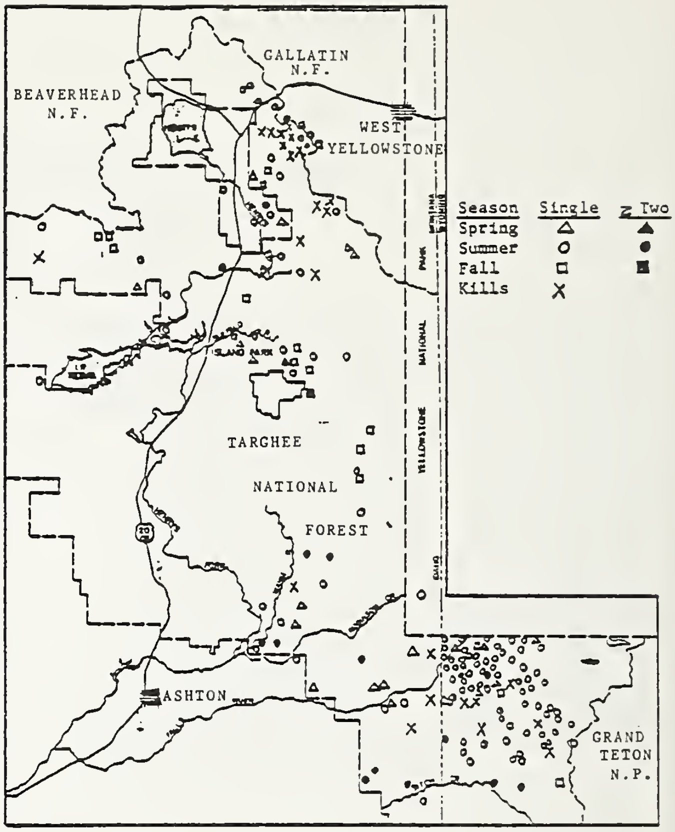

Figure 2.--Summary of grizzly bear observations on the Targhee National Forest, 1965-84.

TIMBER MANAGEMENT--1975 to 1985

Intensive timber management on the Targhee began in the 1960's. Approximately half of the timber base on the Forest is lodgepole pine; a large percentage (80 to 90 percent) of the pine was in a mature timber class by the 1960's and 1970's. The mountain pine beetle began killing large numbers of trees in the late 1960's and 1970's. Early timber management techniques involved selection cutting to remove only the trees killed by the beetle. This type of cutting opened up many timber stands and created favorable conditions for understory shrubs and grasses but generally did not encourage regeneration of lodgepole pine. Clearcutting of stands followed by extensive mechanical soil scarification is the technique used now to regenerate stands.

Timber management was the first program to receive formal consultation with the U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act. In 1978, a "no jeopardy opinion" was received with the timber management program, providing certain management actions were implemented in a "discreet manner." The following is a summary of the recommended management actions:

1. Miles of road in areas of grizzly use (Situation 1 habitat) should remain at or below the present (1978) number.

2. Heavy concentrations of dead trees resulting from the pine beetle epidemic could cause multi-thousand acre fires, which would be detrimental to the cover needs of the bear. Timber harvesting to break up this fuel loading was considered beneficial with the following recommendations:

a. Selection cuts should be used wherever and whenever possible and clearcuts should be minimized. Understory forage species, such as tall huckleberry (*Vaccinium globulare*), would be protected and possibly enhanced with selection type cutting.

b. When they are necessary, clearcuts should be irregularly shaped to increase ecotonal areas and should not exceed 100 meters across. Where clearcuts are used, soil scarification should be minimized by broadcast burning slash whenever possible; dozer piles should be kept small and placed in areas most severely impacted by machinery.

c. Uncut strips or cover strips should be left around clearcuts and around open grizzly feeding sites such as avalanche chutes, meadows, shrubfields, sidehill parks, and creek bottoms. To assure cover adequacy, cover strips, even in the form of dead standing or fallen trees should remain.

d. When possible, logging should be restricted to the winter months in areas having abundant bear foods (generally large mesic sites) to reduce soil scarification, which destroys rhizomatous plants and root crowns of some shrubs.

e. When more soil scarification is required for conifer regeneration than is obtained in the above slash disposal methods, scarification should be restricted to highly disturbed sites or to a strip configuration through the clearcuts.

The Targhee National Forest is often called the "pocket gopher capital of the world," and successful regeneration of cutting units often will not occur until intensive gopher control work is completed. The most commonly used technique for pocket gopher control is to use 0.5 percent strychnine-treated oats placed underground in burrows at a rate of 1/2 to 1 1/2 lb/acre the first year of treatment, and 1/4 to 1/10 lb/acre the second and third years.

With regard to this part of the timber management program, the 1978 formal consultation recommended that strychnine bait not be used to control pocket gophers in grizzly bear biological centers. The Environmental Protection Agency, however, had previously determined that underground use of strychnine bait did not significantly increase the risk to nontarget wildlife (Hegdal and Gatz 1976).

In 1979, the Forest Service reinitiated formal consultation with the Fish and Wildlife Service in order to address the potential hazards of this program for the grizzly bear. To adequately assess the potential hazards, biologists from the Denver Wildlife Research Center designed and conducted a study. At the conclusion of this research, a biological opinion was received that the use of strychnine grain bait underground is not likely to jeopardize the continued existence of the grizzly bear. In issuing this opinion, the following additional conservation measures were recommended:

1. An area should be reforested as soon after harvest as possible. Immediate reforestation reduces problems with pocket gophers and the amount of strychnine needed.

2. The feasibility of other control techniques such as vexar tubes or zinc phosphide should be explored. This research has subsequently been completed (Barnes and Evans 1982; Anthony and Barnes 1978).

3. Areas scheduled for treatment should be thoroughly surveyed for evidence of grizzly use such as tracks, diggings, or actual sightings. If grizzly use is noted, treatment plans should be delayed until the bears leave the area. If grizzly use becomes evident after baiting has commenced, treatment should be halted immediately.

4. Baiting procedures by contracted crews should be closely regulated and inspected by the Forest Service to ensure that the minimum amount of grain is deposited in each bait set and in each treatment site. Penalties should be assessed for too many sets and too much grain in each set. The Forest Service should consider developing a tool to administer a predetermined amount of baited grain per set when setting bait by hand.

Following these two formal consultations with the Fish and Wildlife Service, the Targhee National Forest in 1980 began to develop the Forest Land Management Plan. For the purpose of simplicity, the discussion of how timber management and the needs of grizzly bear were coordinated in the Targhee Forest Plan is confined to the Situation 1 habitat area south of Yellowstone National Park (fig. 1). This management area contains extensive stands of lodgepole pine, most of which are dead or dying and will be lost to commercial use if not salvaged within the next 15 years. In addition to the obvious loss of products if salvage operations were not undertaken, future productivity is jeopardized as the untreated and dying stands naturally regenerate at a much slower rate than treated stands. In addition, untreated stands become infested with mistletoe from the residual overstory.

A first step in the coordination of timber with grizzly bear needs was to inventory the timber resource and to determine exactly how much was available. The inventory identified 50,000 acres of mature lodgepole pine on slopes less than 40 percent that could conceivably be harvested while maintaining acceptable soil and water conditions. In this management area, as in several others, the planning team did not consider salvage of lodgepole during the first decade (1981-1990) in areas where advanced logging systems would be required, because massive amounts of dead material were available for salvage in more economically and environmentally suitable areas.

It was estimated that the 50,000 acres of mature lodgepole would yield 350 million board feet; however, because most of the lodgepole was dead and had been for some time, salvage would only be possible during the next 15 years. In planning terms, this level of activity is designated as the maximum unconstrained timber benchmark (fig. 3).

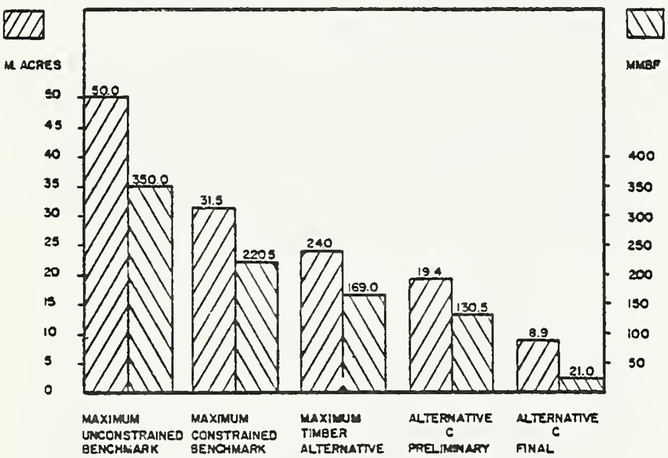

Figure 3.--Acres and volume of lodgepole pine timber management benchmarks and alternatives in Situation 1 habitat south of Yellowstone National Park.

Obviously, it was not possible or desirable to cover the entire management area within 15 years. The interdisciplinary team evaluated the minimum needs of other resources such as recreation, range, wildlife, and watershed and concluded that to maintain basic minimum levels of other resource use, the total area and volumes that could be realized during the first decade were 31,500 acres and 220.5 million board feet. This level of activity is designated as the maximum constrained timber benchmark (fig. 3).

Up to this point, the emphasis was on developing baseline data from which alternatives could be developed. These alternatives projected timber outputs ranging from 12,351 to 24,027 acres, and 83.2 to 169.0 million board feet. Alternative C, the preferred alternative, called for treatment of 19,370 acres with a projected volume of 130.5 million board feet (fig. 3).

During a subsequent period of "ground truthing" by ranger district personnel, it became evident that the projections for timber outputs were too high and that they could not be achieved if the needs of the grizzly bear were to be met. Several factors contributed to this perception:

1. The initial reductions for wildlife were based on general wildlife considerations and did not consider the special needs of the grizzly bear.

2. Although there was still a considerable amount of mature lodgepole cover within the area, quality of cover was poor because of limited dispersion.

3. There had been fairly extensive harvest of "dead only" areas, leaving stands of mature lodgepole that contained low volumes and provided limited cover.

4. The level of existing activity had not been carefully balanced against projected future activity and the needs of the bear.

To correct these deficiencies, district personnel stratified the management area by portraying grizzly habitat components and showing precisely where past timber activities had occurred and where future activities were projected.

In addition, the management area was further stratified into "bear subunits" (fig. 4). This stratification allowed planners to better

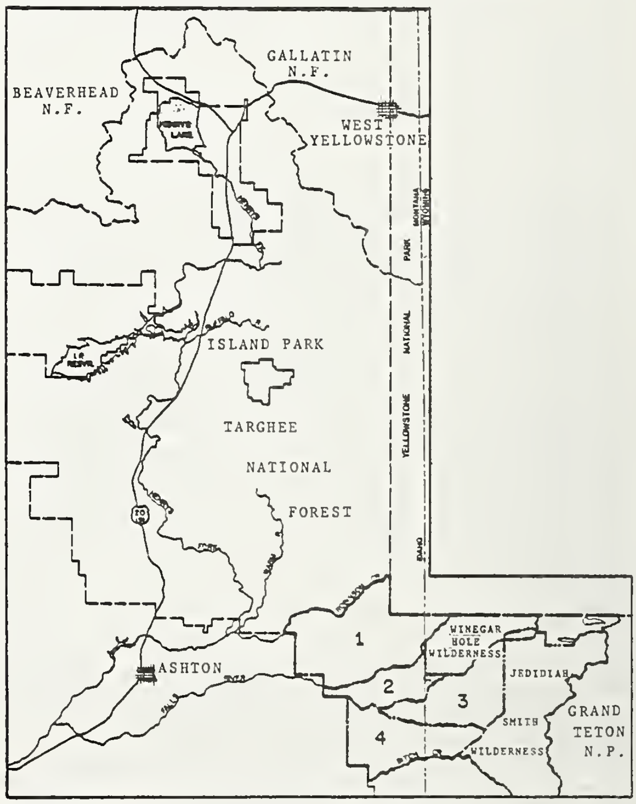

Figure 4.--Situation 1 habitat south of Yellowstone National Park, subdivided into four bear management subunits.

distribute activities and to designate areas where development would not occur until activities in other subunits were concluded.

Specific output levels and cultural practices for timber harvest as well as levels of cover that would be maintained were identified and carried forward as management direction in the Land Management Plan as follows:

1. Harvest timber and other products, reforest cutover areas, and accomplish timber stand improvement and silvicultural examination during the first decade as shown in table 1.

2. The following cultural practices apply to lodgepole pine stands:

Area	Maximum size clearcut	Minimum average width of leave strip
	Acres	Feet
Elk summer concentration areas	40	1/ 600
Elk calving areas	40	1/ 600
Elk/deer winter range	40	1/ 600
Situation 1 grizzly bear habitat	2/ 40	1/ 800

3. Concentrate all timber management activities within the shortest time period and smallest possible area.

4. Maintain security areas of at least 5,000 acres within subunits 1, 2, 3, and 4 for duration of high level of human activity.

5. Manage Situation 1 subunits to provide the following levels of cover:

Subunit	Acres	Conifer cover 3/ 1981	Conifer cover 3/ 1990	Aspen	Unproductive forest
1	32,400	60	66		
2	8,960	65	65		
3	18,080	74	74		
4	19,900	60	65		
Total	79,340	65	66	7	1

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[1]Leave strips having a percentage of dead trees high enough to prevent their serving as cover may be harvested before adjacent clearcuts provide cover, if contiguous cutting units have been planted or naturally regenerated. Natural regeneration will be considered accomplished after the third year inspection reveals natural regeneration meets stocking level standards.

[2]Each sale area, and the individual stands within, will be evaluated for key grizzly habitat components for final unit size determination. Clearcut size may exceed 40 acres (up to 100) if cutting unit configuration is such that distance to cover does not exceed 300 ft over 80 percent of the unit.

[3]Does not include aspen or unproductive forest.

The result was that lodgepole pine harvest was reduced to 8,925 acres with a projected volume of 21.0 million board feet (fig. 3).

Although this level of timber harvest will treat considerably fewer acres of decadent lodgepole than necessary to properly manage timber stands from a purely timber silvicultural standpoint, this strategy is considered necessary to adequately provide for the needs of the grizzly bear.

LIVESTOCK GRAZING--1975 to 1985

Perhaps the oldest resource use occurring on the Targhee National Forest is domestic livestock grazing. Many of the permits for grazing allotments date to the time when the Forest was officially established. Livestock permittees on National Forest lands legally have a contract with the government. Grazing privileges are guaranteed to the livestock permittee as long as the permittee is willing to abide by the conditions of the permit. Permits cannot be cancelled unless violations of the permit requirements occur. In 1975, when the grizzly bear was officially classified as a threatened species, 11 sheep allotments and four cattle allotments were permitted and in use in the areas that were eventually to become Situation 1 grizzly bear habitat (table 2; fig. 5).

Sheep grazing generally occurs from the first part of July until the first part of September (approximately a 72 day grazing period). A sheepherder stays with the sheep full time while they are on the Forest.

Cattle grazing generally begins around the first part of July but continues longer into the fall, generally to the first part of October (approximately a 92 day grazing period). Cattle allotments are fenced into various pastures. Unlike sheepherders, cattlemen are generally not continually with their livestock. Occasional fence mending, herding, and movement of the cattle between pastures is required.

Table 1. Timber management outputs for the first decade (1981-90) in management area 12

Timber type	Acres planned for harvest	Estimated outputs MBF's 1	Acres to be reforested: Backlog	Acres to be reforested: Current cutover (sawtimber)	Acres to be reforested: Current cutover (firewood and other products)	Acres timber stand improvement
Douglas-fir	561	2,000	-	-	-	
Lodgepole	3,225	16,000	425	3,200	-	602
Firewood and other products	5,700	5,000	-	-	5,700	

[1]Includes approximately 4,550 acres and 10 million board feet (not a part of target) that may not be available depending on future application of grizzly bear guidelines to on-the-ground conditions.

Table 2. Summary of permitted livestock grazing in situation 1 grizzly bear habitat, 1975

	Allotment name	Type	Permitted grazing use	In Use
1.	Targhee Mountain	Sheep	1,200-ewe band	Yes
2.	East Targhee	Sheep	1,000-ewe band	Yes
3.	Dry Creek	Sheep	850-ewe band	Yes
4.	Jesse Creek	Sheep	850-ewe band	Yes
5.	Reas Pass	Sheep	1,000-ewe band	Yes
6.	Garner Canyon	Cattle	26 AUM's 1	Yes
7.	Twin Creek	Cattle	198 AUM's	Yes
8.	Rock Creek	Sheep	700-ewe band	Yes
9.	Fall River Ridge	Cattle	2,420 AUM's	Yes
10.	Squirrel Meadows	Cattle	4,699 AUM's	Yes
11.	Dog Creek	Sheep	1,000-ewe band	Yes
12.	Squirrel Meadows	Sheep	1,000-ewe band	Yes
13.	South Boone	Sheep	1,000-ewe band	Yes
14.	Grizzly Creek	Sheep	1,000-ewe band	Yes
15.	Middle Bitch Creek	Sheep	1,000-ewe band	Yes

Total: 11 sheep allotments in-use: 10,600 ewes
4 cattle allotments in-use: 7,343 AUM's

[1]Animal unit months.

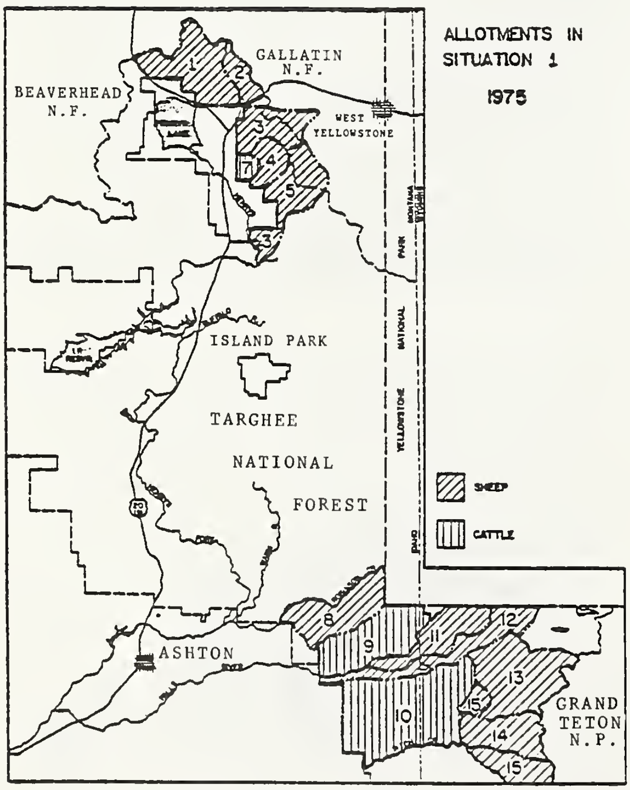

Figure 5.--Livestock allotments in use in Situation 1 habitat in 1975 (numbers refer to allotments listed in table 2; allotment number 6 is not shown).

Although some conflicts between grizzlies and cattle have occurred, the major problems have been between sheep and bears.

Table 3 shows the number of grizzly bears estimated to have been killed since 1960. To place the data in table 3 in proper perspective, two factors must be considered:

1. Until August 1975, when the grizzly was declared a threatened species, a grizzly bear preying on sheep was treated the same as any other predator. Thus kills before 1975 were legal.

2. Of the eight kills estimated to have occurred since 1975, only two were actually verified.

Table 3.--Targhee National Forest estimated grizzly bear mortality associated with Situation 1 allotments[1]

	Sheep Allotments	
Years	Two Top/Reas Pass	Squirrel Meadows/Boone
1960	2	
1965	1	
1966	1	
1967	1	
1968	1	
1969	2	
1970	5 (6)	2
1971	1	2
1972	2	1
1973	1	2
1974-75	2	1
1976-79		7
1980-84	0	0

[1]1960-1979 estimates by John Weaver based upon grizzly bear mortality report by Carole Jorgensen (1979); 1980-1984 compiled by authors.

In 1981, the Forest completed a biological evaluation of "Man--Grizzly Bear Conflicts Related to Sheep Grazing in Essential (Situation 1) Grizzly Bear Habitat." This document was the result of 5 years of research and subsequent alterations in the management and alignment of domestic sheep allotments. It was submitted to the Fish and Wildlife Service for formal consultation and received a no jeopardy opinion. Key provisions of the biological evaluation and resulting no jeopardy opinion are as follows:

1. The number of sheep allotments was reduced from 11 to seven. This reduction allowed the Forest and permittees to avoid historic high conflict areas; it also allowed more room to move sheep should a conflict or potential conflict occur.

2. Several allotment boundaries were changed to avoid areas of historic conflict.

3. Permittees would not use traps, snares, or poison to control black bear predation. Free-ranging black bears would not be taken except under State hunting regulations. Predator control for bears would only be done by Federal trappers.

4. Should a conflict occur or appear imminent between sheep and a grizzly bear, the sheep will be moved or, if necessary, removed from the allotment until the conflict is resolved.

5. The Forest Service would provide a full-time monitor during the sheep grazing season.

6. The permittees would cooperate in the monitoring program by reporting locations of sheep kills or other incidents related to grizzly bear conflicts.

7. Any action taken by the permittees or their agents that violated the Endangered Species Act would be grounds for canceling the permit.

8. Camps would be maintained as directed to reduce chances of attracting bears.

9. The allotment annual plan of use would designate areas to be grazed and their season of use.

In 1983, the Forest proposed and evaluated the conversion of one sheep allotment (Rock Creek) to a cattle allotment. The Forest Service consulted informally about the conversion with the Fish and Wildlife Service, which favored the proposal. The number of sheep allotments within Situation 1 habitat was subsequently further reduced to six.

The Draft Targhee Land Management Plan presently permits six domestic sheep allotments and five cattle allotments within Situation 1 habitat. This is in agreement with the previous formal consultations with the Fish and Wildlife Service.

In 1983, a radio collared female grizzly bear (known as No. 38) and her two yearling cubs found sheep grazing on the Two Top allotment. A detailed accounting of this incident has been prepared by the Forest Service (1983). When No. 38 and her two cubs began using private land and Situation 3 habitat, they were trapped and relocated into Yellowstone National Park.

Radio tracking in the fall by the Interagency Grizzly Bear Study Team indicated that they returned to their normal denning area. Using the best biological data possible, it was determined that the sow and cubs would probably return to the Two Top allotment. The Forest Service, therefore, directed the permittee to use a different allotment during the 1984 grazing season. The permittee voluntarily agreed to graze a different allotment again in 1985.

Economic conditions have not been favorable for many sheep ranchers in recent years; some have gone out of business, at least temporarily. As a result, two additional sheep allotments have been vacant in Situation 1 habitat. Table 4 and figure 6 summarize livestock grazing in Situation 1 habitat for 1984 and 1985. Compared to the level of grazing in 1975, the number of sheep allotments in use has declined by 73 percent and the number of sheep being grazed by 72 percent. The amount of cattle grazing has remained the same.

Depending primarily on the economics of sheep ranching the vacant allotments in Situation 1 habitat may be permanently closed, or suitable portions may be considered for conversion to cattle allotments. Direction in the Forest Plan specifies that permits for grazing sheep in Situation 1 grizzly bear habitat that are waived back to the government will not be reissued.

Full-time monitoring is occurring on all sheep allotments still in use within Situation 1 habitat.

At the present time, grizzly bears on the Targhee National Forest have fewer opportunities for conflicts with sheep than at any time since the Forest officially came into being.

Drafts of the Targhee's final plan and final environmental impact statement were submitted to the Fish and Wildlife Service for formal consultation. It was the opinion of the Fish and Wildlife Service that "implementation of the Proposed Targhee National Forest Plan ... is not likely to jeopardize the continued existence of the ... grizzly bear."

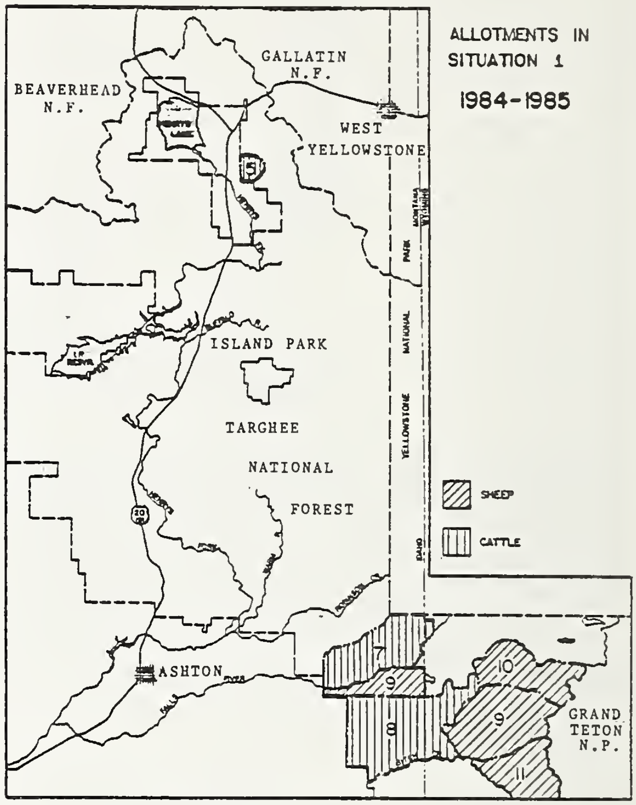

Figure 6.--Livestock allotments in use in Situation 1 habitat in 1984 and 1985 (numbers refer to allotments listed in table 4; allotment number 4 is not shown).

Table 4.--Summary of permitted livestock grazing in Situation 1 grizzly bear habitat, 1984 and 1985

	Allotment name	Type	Permitted grazing use	In use
1.	Targhee Mountain	Sheep	1,200-ewe band	No
2.	East Targhee	Sheep	1,000-ewe band	No
3.	Two Top	Sheep	1,200-ewe band	No
4.	Garner Canyon	Cattle	26 AUM's [1]	Yes
5.	Twin Creek	Cattle	198 AUM's	Yes
6.	Rock Creek	Cattle		No
7.	Fall River Ridge	Cattle	2,420 AUM's	Yes
8.	Squirrel Meadows	Cattle	4,699 AUM's	Yes
9.	Squirrel Meadows	Sheep	1,000-ewe band	Yes
10.	South Boone	Sheep	1,000-ewe band	Yes
11.	Middle Bitch	Sheep	1,000-ewe band	Yes

Total: 3 sheep allotments in-use: 3,000 ewes
4 cattle allotments in-use: 7,343 AUM's

[1] Animal unit months.

REFERENCES

Anthony, Richard M.; Barnes, V. G., Jr. Vexar plastic netting to reduce pocket gopher depredation of conifer seedlings. In: Proceedings, 8th vertebrate pest control conference.; Davis, CA: University of California; 1978: 138-144.

Anthony, Richard M.; Lindsey, G. D.; Evans, J. Hazards to ground squirrels and other selected species of wildlife from strychnine baiting for pocket gophers. Denver, CO: U.S. Department of the Interior, Fish and Wildlife Service, Denver Wildlife Research Center; 1983. 10 p.

Barnes, Victor G.; Evans, J. Evaluation of zinc phosphide bait for control of pocket gophers on forest land. Denver, CO: U.S. Department of the Interior, Fish and Wildlife Service, Denver Wildlife Research Center; 1982. 20 p.

Blanchard, Bonnie M. Grizzly bear habitat relationships in the Yellowstone area. In: Bears--their biology and management: selection of papers from the 5th international conference on bear research and management; 1980; Madison, WI: International Association for Bear Research and Management; 1983: 118-123.

Griffel, David; Predator-livestock relationships in summer on the Targhee National Forest, Idaho. In: Proceedings, symposium on wildlife-livestock relationships; 1981; Coeur d'Alene, ID. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station; 1981: 295-305.

Griffel, David. Bear-livestock interaction study. Annual report-1976. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; 1976. 15 p.

Griffel, David. Bear-livestock interaction study. Annual report-1977. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; 1977. 27 p.

Griffel, David. Bear-livestock interaction study. Annual report-1978. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; 1978. 16 p.

Hegdal, P. L.; Gatz, T. A. Hazards to wildlife associated with underground strychnine baiting for pocket gophers. In: Proceedings, 7th vertebrate pest control conference, Davis, CA: University of California; 1976: 258-266.

Jorgensen, C. J.; Allen, A. Grizzly bear study. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; 1975. 45 p.

Jorgensen, C. J. Bear-livestock interactions, Targhee National Forest. Missoula, MT: University of Montana; 1979. 150 p. M.S. thesis.

Jorgensen, C. J. Bear-sheep interactions, Targhee National Forest. In: Bears-their biology and management: selection of papers from the 5th international conference on bear research and management; 1980; Madison, WI. International Association for Bear Research and Management; 1983: 191-200.

Knight, Richard R.; Judd, S. L. Grizzly bears that kill livestock. In: Bears-their biology and management: selection of papers from the 5th international conference on bear research and management; 1980; Madison, WI. International Association for Bear Research and Management; 1983: 186-190.

Knight, Richard R.; Blanchard, B. M.; Kendall, K. C. Yellowstone grizzly bear investigations. Annual report of the interagency grizzly bear study-1980. Bozeman, MT: U.S. Department of the Interior, National Park Service; 1981. 55 p.

Mealey, S. S. Method for determining grizzly bear habitat quality and estimating consequences of impacts on grizzly habitat quality. In: Guidelines for management involving grizzly bears in the Greater Yellowstone Area. U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, National Park Service; 1979. 79-117.

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, National Park Service. Guidelines for management involving grizzly bears in the Greater Yellowstone Area. U.S. Department of Agriculture, Forest Service, and U.S. Department of the Interior, National Park Service; 1979. 136 p.

U.S. Department of Agriculture, Forest Service. Annual sheep grazing-grizzly bear monitoring reports. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; 1981-1984.

U.S. Department of Agriculture, Forest Service. Biological evaluation man/grizzly bear conflicts related to sheep grazing in essential grizzly bear habitat on the Targhee National Forest. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; 1981. 22 p + amendments.

U.S. Department of Agriculture, Forest Service. Threatened, endangered and sensitive plants and animals of the Targhee National Forest. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest; 1982. 100 p.

GRIZZLY BEARS, INSECTS, AND PEOPLE:

BEAR MANAGEMENT IN THE MCDONALD PEAK REGION, MONTANA

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ABSTRACT: Historically, grizzly bears congregate July through September on McDonald Peak in the Mission Mountains on the Flathead Indian Reservation to feed upon an aggregation of ladybird beetles (Coccinelidae) and army cutworm moths (Noctuidae). Recreational use of the McDonald Peak region has increased from essentially no use in the mid-1950's to eight to ten parties per week climbing the Peak in 1980. The Confederated Salish and Kootenai Tribal Council has closed the area to public use from mid-July to October 1 since 1981. Objectives of the closure were to provide for human safety and to protect a site critical to the Mission Mountain grizzly bear subpopulation. The closure will decrease bear exposure to people, possibly reducing the rate of habituation. Since grizzly bears must occupy the heavily populated Mission and Swan valleys in the spring and fall, the closure will allow them to remain at high elevations for a longer time where there are fewer threats to life, fewer opportunities for people-bear conflicts, and better opportunities to gain enough weight on high-protein insects to make interaction with humans later in the year less likely. Although a major concern was the public's response to closing a popular hiking area, visitor compliance was nearly complete and attitudes were positive and supportive. Furthermore, we observed 10, 11, and eight bears in 1981, 1982, and 1983. There were indications the closure aided the bear population by decreasing mortality and increasing bear use of the Peak.

INTRODUCTION

Grizzly bears (Ursus arctos horribilis) inhabit the Mission Range in western Montana. They den above 7,000 ft, spend spring in both the Mission and Swan valleys below 4,000 ft, generally summer above 7,000 ft, and spend fall in the Mission Valley (Servheen 1983; USDI, BIA 1985).

The population is declining because of high mortality from people-bear conflicts in the valleys (Claar and others in press). The Confederated Salish and Kootenai Tribes (CS & KT) and the Bureau of Indian Affairs (BIA) have an active management program to limit this mortality and to reverse the downward population trend (CS & KT and BIA 1981). The management plan's goal is to secure and maintain a viable, self-sustaining population in critical habitat on the Flathead Indian Reservation (FIR). An important element of this plan is to protect habitat and to minimize human-bear competition. The purpose of this paper is to describe the management of a unique area in the Mission Mountains: the McDonald Peak region.

East McDonald Peak, at 9,820 ft, is the highest mountain in the Mission Range with a relief of approximately 6,600 ft in 4 airline miles (fig. 1). The Mission Range is protected by two wilderness areas: an 89,500-acre tribal wilderness area and a 73,000-acre component of the National Wilderness Preservation System (CS & KT 1982). Timberline varies between 7,500 and 8,000 ft, depending upon aspect. Davis (1916), Harrison and others (1969), and Pardee (1950) provide a detailed geologic description of the Mission Mountains; Alt and Hyndman (1972) provide a more general description. Servheen (1981, 1983) and Servheen and Klaver (1983) described the grizzly bear habitat on the FIR.

BACKGROUND ON THE MCDONALD PEAK REGION

Grizzly Bears

Records of grizzly bears congregating on McDonald Peak extend for over 60 years (table 1). Although these records are not complete, they show a consistent pattern of family groups on the Peak from late July through August. Jack Romer (1982) observed "literally hundreds of grizzly bears," mainly females with young, between 1932 and 1956 in his many visits to the Peak.

Bud Cheff, Sr. (1985) observed grizzly bears on McDonald Peak from the late 1920's to the present. He mainly saw the bears in August

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Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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A B

Figure 1.--A, McDonald Peak from U.S. Highway 93 near St. Ignatius, MT. B, Basin on McDonald Peak where the grizzly bears aggregate. Photo is taken from the observation post for censusing.

Table 1..--Historical observation on McDonald Peak

Date	Total	Number of adults	Number of young	Citation
Previous to 1924	1			Elrod (n.d. a)
Following year	7	5	2	Elrod (n.d. a)
Aug. 1924	1	1		Elrod (n.d. b)
Aug. 3, 1932	12			Chapman and others (1955)
July 26, 1946	7	2	5	Underhill and Underhill (1950)
Aug. 3, 1949	3	1	2	Wright (1982)
July 22, 1951	2	2		Wright (1982)
Sept. 19, 1952	0			Wright (1982)
Shortly after Aug. 15, 1953	4	1	3	Wright (1982)
Aug. 23, 1957	1	1		Stockstad (1959)
Approximately Aug. 15, 1965	4	2	2	Pfeiffer (1982)
Approximately Aug. 15, 1966	4	2	2	Pfeiffer (1982)
Summer 1967	1	1		Pfeiffer (1982)
Summer 1977	3	1	2	Pfeiffer (1982)

eating insects on the Peak and grazing in the surrounding meadows. The bears usually gathered in the evenings when the insects became more active. All ages and sexes were observed on McDonald Peak, but females with young were common.

There is some debate about why bears are on McDonald Peak in the summer months. Chapman and others (1955) reported that the bears were eating ladybird beetles (Hippodamia caseyi Coleoptera: Coccinellidae) and army cutworm moths (Euxoa [Chorizagrotis] auxiliaris Lepidoptera: Noctuidae). Shoemaker (Elrod n.d. b, Romer 1982; Chapman and others 1955) observed the bears consuming ladybird beetles. Chapman (Chapman and others 1955) collected 15 scats; nine consisted largely or entirely of army cutworm moths, and none contained ladybird beetles. Pfeiffer (1982) observed bears licking rocks with high magnesium chloride content. Romer (1982) believed the females also gathered to protect their young from males.

Insects

Ladybird beetles make long migrations from prairie valleys to mountaintops for hibernation (Fields and McMullen 1972; Harper and Lilly 1982). Edwards (1957) and Harper and Lilly (1982) believed that ladybird beetles hibernate on mountaintops for protection from the extreme cold of the prairies; the mountain snowpack providing insulation from the cold. Heavy mortality can occur during hibernation as masses of dead bodies may be found in summer months (Chapman 1954; Chapman and others 1955; Edwards 1957).

Aggregation sites in south-central British Columbia (Fields and McMullen 1972) were on south-facing uppermost slopes among fractured boulders covered with lichens. The beetles were in crevices between rocks. These aggregation sites became snow-free earlier in the spring than did other parts of the mountain because of the south aspect, topography, and wind that created shallow snowpacks. Ladybird movements to aggregation sites began in early September and finished by mid-October; dispersal began in early June and was completed by late June. Some ladybirds were at all elevations in July and August, but the greatest densities were in the valley alfalfa fields.

These observations from south-central British Columbia generally describe the situation on McDonald Peak; however, Chapman and others (1955) reported seeing large aggregations of the beetles (5 to 10 gallons could have been collected in a day) on August 3, 1932. They speculated that these could be overwintering beetles since snow fields were still abundant.

Army cutworm moths migrate from the Great Plains in the spring to mountaintops for estivation in order to escape the high temperatures (Cook 1927; Pepper 1932; Pruess 1967; Walken 1950). The same individuals return to the plains in the fall (Pruess 1967). Before the moths migrate, their bodies are approximately 70 percent protein. When they return in the fall, the moths have gained weight as fat (Pruess 1967); so the moths are active during estivation (Chapman and others 1955; Pruess 1967; Johnson 1969). They are only sometimes diurnally active at treeline, but are usually found near alpine meadows in dry places under rocks during the day (Pruess 1967).

Army cutworms are not a serious pest in the Mission Valley (Bratton 1985). The closest area with a large army cutworm infestation is the Three Forks, MT, region (Jensen 1985), approximately 160 airline miles from the Mission Valley. Army cutworm moths apparently are able to migrate 300 miles between spring and summer (Pruess 1967).

People

Recreational use of the McDonald Peak Basin has increased substantially since 1950. Stockstad (1959) described Cliff Lake, located at the base of McDonald Peak, as having no signs of human use. He had "never seen an area that was as free from the mark of man."

By 1978, the situation at Cliff Lake had drastically changed (Rockwell and others 1978). The lake had 17 campsites, 15 of which could accommodate one or two tents, had one or two fire rings, and had lost a moderate amount of vegetative ground cover. The other two sites had moderate loss of vegetative ground cover. The Cliff Lake and McDonald Peak area received 1,400 visitor-days over a 136-day season in 1979, as recorded at the Glacier Lake trailhead (CS & KT 1985). These data do not represent an exceptionally high level of use relative to surrounding areas, but do indicate a strong trend of increasing use.

McDonald Peak, besides being the highest peak in the range, is also the most scenic. It is within 4 miles of a major north-south highway, U.S. 93. Easily seen from this popular route to Glacier National Park, it is within 40 miles of Missoula, population 33,000 and 70 miles from Kalispell, population 11,000. The Peak is easily climbed from several faces without technical equipment or skill. The chance of observing grizzly bears on the Peak has been another major attraction (Underhill and Underhill 1950).

People have seldom had confrontations with grizzly bears on the Peak, although observations of bears were common. The basin on McDonald Peak where the bears aggregate is also the best route for climbing the mountain. McDonald Peak and the surrounding basins are above timberline so few escape routes exist if someone surprises a bear. Before 1980, we had no formal reporting system for these close encounters of the ursid kind, but we know of at least one report. A hiker played dead after observing a bear at close range. The

bear smelled the hiker and left; neither bear nor hiker was injured. We have received only two reports of bear-human confrontations since 1980, both in 1981.

MANAGEMENT OF THE MCDONALD PEAK AREA

Management direction was being developed for the McDonald Peak area between 1980 and 1982. The Council of CS & KT was developing a wilderness management plan for the area (CS & KT 1982) and they approved the FIR Grizzly Bear Management Plan (CS & KT and BIA 1981) in June 1981. One provision in the grizzly bear plan allowed the Chief of Tribal Fish and Game Conservation Department to close areas when grizzly bears remain in a specific backcountry area.

Several events led to the decision to close an area surrounding McDonald Peak in 1981. During a routine radio-tracking flight on July 22, 1981, an unmarked female with cubs was observed on McDonald Peak; subsequent flights revealed an additional female but with older young. We received two reports of parties of climbers having encounters with grizzly bears on the Peak.

The Tribal Council decided that the region surrounding McDonald Peak should be closed to all public use on July 28, 1981. The proposed date to reopen the area was originally September 15, and later extended to October 1, since grizzly bears were still on the Peak in mid-September.

The closed area included all lands surrounding McDonald Peak that grizzly bears might use in their normal movement patterns (fig. 2). Closure of this area allows the bears to remain undisturbed and without contact with people. Additionally, its topographical boundaries make it easily defined to the public.

Objectives of this closure were to ensure human safety and to protect a critical site for grizzly bears.

These objectives made the closure different from those of other agencies. Historically, closures were short term and primarily to protect human safety. This 10,000-acre closure was to allow bears an extended time free from human disturbance. We expected the closure to last a minimum of 6 weeks and were attempting to slow the rate of habituation.

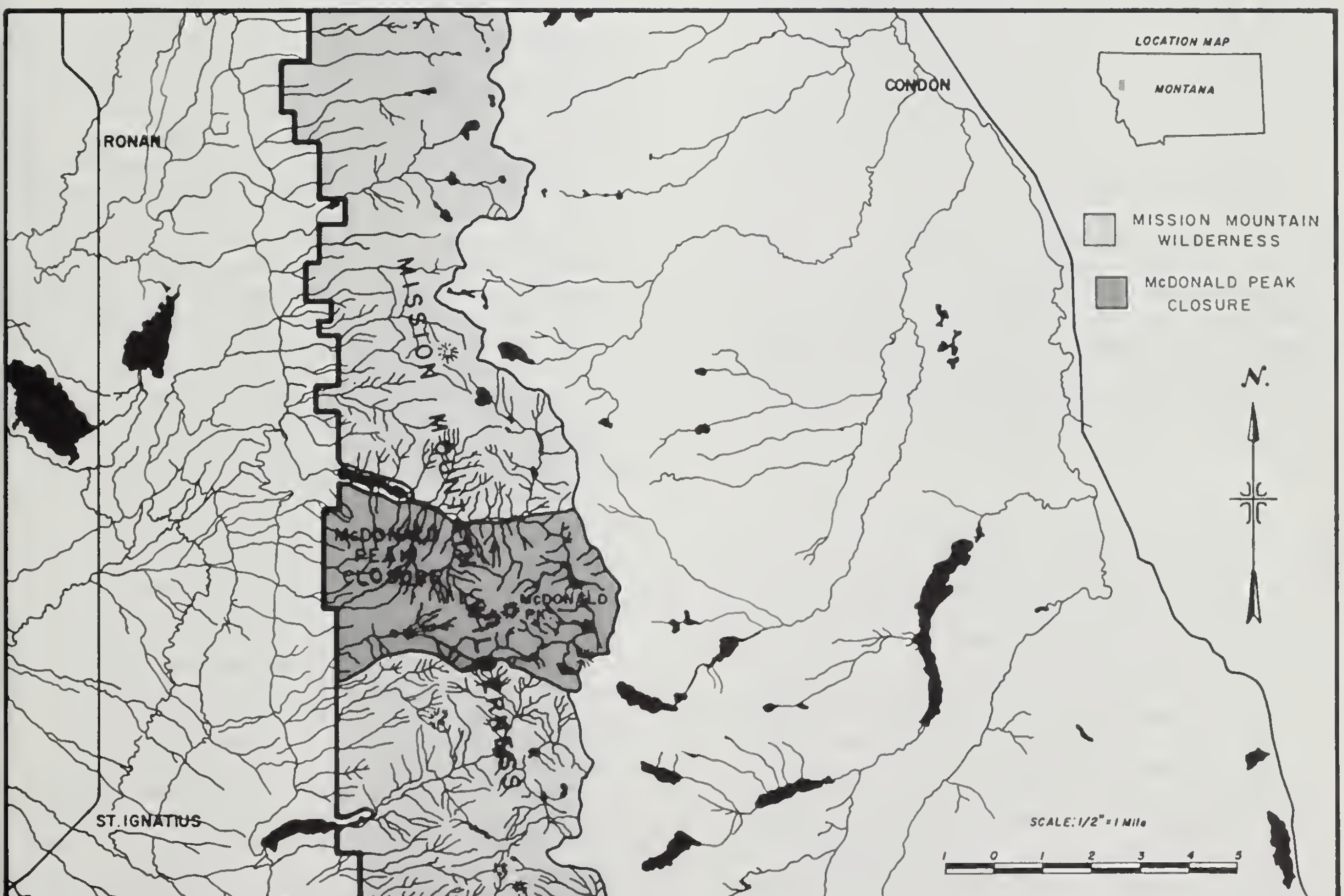

Figure 2.--Mission and Swan valleys showing the McDonald Peak Grizzly Bear Closure and the CS & KT Mission Mountain Wilderness.

Closing the area to human use would allow the bears to feed undisturbed. Few bears are killed at high elevations in the Mission Range (Claar and others in press) so the longer the bears remain undisturbed on the Peak, rather than being forced to move to the Mission Valley, the safer they would be. Because their stay in the Mission Valley below 4,000 ft would be shorter, the Valley's residents would also benefit. Finally, if the bears were well fed on insects throughout the summer, we hoped they would be less tempted to depredate livestock or become involved in other causes of bear-human conflict.

We did not want bears to become habituated to people, especially since they must live close to residences in the spring and fall (Servheen 1983). Residents of the Mission Valley have been intolerant of bears that were not wary of people. McArthur Jope (1982), Jope (1985), and McCullough (1982) believe that frequent and innocuous contacts with people resulted in habituation.

Habituation toward people of female grizzly bears with young has not been observed and probably occurs at a slower rate than for the rest of the grizzly bear population (McArthur Jope 1982, 1983). Because females with young were an important segment of the bear aggregation, we did not want females teaching their young aggression toward people. This was especially important to us, because many of these bears would be living next to homes a few weeks later (Servheen 1983). Additionally, females with young are more likely than other bears to avoid areas with high human use (McArthur Jope 1983). McArthur Jope (1982) recommended prohibiting human use of areas used by females with young.

To inform the public of the closure, trailheads leading to the closed area were posted. Some access roads were temporarily closed with a cable. Adjacent U.S. Department of Agriculture, Forest Service, ranger districts on the Flathead and Lolo National Forests notified their visitors of the closure at ranger stations and in the backcountry. They posted explanatory signs at trailheads on their land leading into the closed area.

CS & KT and BIA staff patrolled both back and front country locations. Management staff did not enter the closed area, but monitored the area from the perimeter. The primary purpose of these patrols was to inform and educate visitors, but personnel had enforcement capabilities as well. Public reaction was favorable. Visitors were happy to learn of the closure because they did not want to camp or hike with a high density of grizzly bears, and they wanted to protect and restore the bear population. The only negative comments were that we should not be specific when describing the bears' location because of concern about poaching and other sources of disturbance. The only group we discovered intentionally violating the closure was a Boy Scout troop from Missoula.

A major concern was the public response to closing a popular hiking area. We prepared two formal press releases and gave numerous interviews to radio stations and newspapers. These interviews gave us a chance to explain the need to exclude people from the area and helped to secure public support. To further enlist the support of backcountry users, we spoke to local wilderness groups, mountaineers, backcountry horsemen, and other users between the end of the 1981 closure and start of the 1982 closure. To date, we have not received any complaints about the closure of McDonald Peak during the height of the climbing season. We included a section on the closure in the FIR grizzly bear management slide program, which is presented to a variety of audiences about twice a month during the year.

The procedures established in 1981 have been used in subsequent years. The day the closure starts depends upon when the bears arrive on the Peak. We use fixed-wing aircraft to determine presence or absence of bears. Flights begin in mid-July and continue as needed. The closure began on July 21, July 27, and August 3, 1982, 1983, and 1984, respectively. The closure was lifted on October 1 each year.

MONITORING THE GRIZZLY BEAR POPULATION

The aggregation of grizzly bears on McDonald Peak appeared to be a unique opportunity to monitor the population in the Mission Range. We used fixed- and rotor-wing aircraft and ground observations, and the latter were the most useful. We established a base camp approximately 1 airline mile from the bears on a ridge to the southwest. Bears were observed with binoculars and spotting scopes early in the morning until they bedded for the day and again in the late afternoon until dark. Personnel generally spent 3 or 4 days per week in the camp for 2 separate weeks. We recorded age (adult, subadult, yearling, or cub), coat characteristics, and group size of all bears observed. These notes helped to distinguish individuals. The best time to count the bears on McDonald Peak was mid-August. We summarized observations by the census period, by the week, and by the field season. The total number of bears using the Peak in a field season was estimated using the descriptions of bears, the total maximum count, and completing the age/sex categories.

The number of bears observed was lower when aircraft were used. Helicopters gave the poorest results. We watched a female with cubs hide when she first heard the helicoptor. This is comparable to Ballard and others' (1982) observation that females with young were more secretive than other bears. Fewer bears were observed from fixed-wing aircraft than the ground observations; however, we occasionally had good results. We plan to use the technique of Maggnuson and others (1978) of simultaneously observing bears from the ground and fixed-wing aircraft to achieve a better population estimate.

The number of bears observed was 10, 11, and eight in 1981, 1982, and 1983, respectively (table 2). Servheen (1983) estimated the grizzly bear population in the Mission Range to be 25. The sex/age composition is comparable to the historical accounts. We hope these observations will allow us to estimate recruitment of cubs at 6 months, survivorship of cubs to yearlings, and population trend. The number of cubs explains the variation between years. Apparently, no cubs or yearlings died.

An adult female with yearlings radio-tracked in 1979 provided data on the movement patterns of bears using McDonald Peak. She was on the Peak between July 11 and September 13. Of the 42 relocations between July 1 and September 20, 50 percent occurred on the mountain. Between July 1 and August 10 she spent 32 percent (n=22) of the time on the Peak, with several abrupt movements between the mountain top and the valley bottom. Between August 11 and 31, all her relocations (n=13) were on McDonald Peak. Between September 1 and 20, 12 percent (n=8) were on the Peak. She may have left McDonald Peak in early September because of the changing nutritive value of the vegetation and insect migration. The trip to McDonald Peak on September 13 may have been to feed on returning ladybird beetles.

The observations of grizzly bears on McDonald Peak in recent years are consistent with this pattern. Bears were on the Peak for 44, 54, and 39 days in 1981, 1982, and 1983, respectively. The greatest number of bears observed from the ground camp occurred on approximately August 20. Of the 12 bears for which it was possible to determine length of stay, 10 remained on the Peak for more than 20 days.

We are using these data as part of the overall data base on grizzly bears. We will not depend solely on this trend information until the technique is validated, because it may be biased in some fashion or reflect the status of only a portion of the population. We need to determine from how large an area the bears are attracted to the Peak, the percentage of the population that uses McDonald Peak, when and if males stop using the Peak, and how consistently individuals use the Peak.

Of special concern is the monitoring of a population in its best habitat. Kruck (1977) found that a mountain goat (Oreamnos americanus) population was declining, but the trend count from the best winter range was stable because the goats moved into this area when vacancies occurred. If grizzly bear monitoring followed this pattern, the population could collapse in the Mission Mountains even though numbers observed in prime habitat would remain stable until it was too late to correct the situation. Other sources of information we use to monitor the population are kill statistics, movement of radio-collared bears, trapping success, and direct observation in other areas of the range.

If this technique proves useful, it may be applied to other areas of the Northern Continental Divide Grizzly Bear Ecosystem. Places like Kintla Peak (Kendall 1985) and Bear Valley (McArthur Jope 1982) in Glacier National Park, and Scapegoat Mountain (Craighead and others 1982), for example, have aggregations of grizzly bears eating insects, roots, or berries. These areas and probably many more may be used to monitor grizzly bear populations. Care must be taken to ensure that the animals using these concentration areas are representative of the total population.

EVALUATION AND CONCLUSIONS

McDonald Peak is mainly used by females with their young. Radio-tracking of three male grizzly bears from July through August showed that they used lower elevation habitat (USDI, BIA 1985). Females may use the Peak to protect their young from males, which use different areas. Russell and others (1979) found that females with young were mainly on upper slopes and in hanging valleys, where escape routes were plentiful. They believe that this habitat use was to avoid males which used the valley bottoms or lower slopes.

Table 2.--Number and classification of grizzly bears observed on McDonald Peak, 1981-1983

Year	Total	Adults[1]	Female adults	Cubs	Yearlings	Subadults[2]
1981	10	2	2	2	2	2
1982	11		3	3	2	3
1983	8	2	1		3	2

[1] Adults of unknown sex.
[2] Ages 2-5 years.

Insect ecology needs to be better understood. It is necessary to know where the insects come from and their population dynamics in order to understand yearly changes in grizzly bear use of the mountain and their food habits. Additionally, army cutworms are serious agricultural pests and heavily sprayed with insecticides; grizzly bears may be bioconcentrating these organochlorides. Ladybirds are reported to taste bad to predators (Borror and others 1976) and thus may explain why they are not always found in scats. We need to determine the food value of the ladybirds and army cutworm adults to better understand their value to the bears. Pfeiffer's (1982) observation that the basin where the grizzly bears are found has areas high in magnesium chloride may explain why the army cutworm moths and ladybird beetles migrate there.

It is too early to determine the success of the McDonald Peak management program. There are, however, indications it may be working. Nine grizzly bears died in the 4 years before the closure, 1977-1980; only three died in the 4 years following the McDonald Peak closure (Claar and others in press; USDI, BIA 1985). A female grizzly bear that did not use the insect concentration when radio-tracked in 1978 and 1979 was observed on the mountain in 1982 and spent 3 weeks on the Peak in 1983. Visitors' compliance was nearly complete, and they supported the closure. These results and those from areas which subsequently adopted this plan provide some encouragement that this management action is working.

ACKNOWLEDGMENTS

Many people of the Confederated Salish and Kootenai Tribes staff assisted with this program. Tribal Fish and Game Conservation officers, especially Charles Morigeau, Pablo Espanosa, and Fred Matt of the Tribal Wildland Recreation Department helped with backcountry patrolling. Pat Hurley-Rogers gave valuable suggestions which improved earlier drafts of this paper. This paper is dedicated to the memory of Dennis A. Dumont, Chief of the Tribal Fish and Game Conservation Department.

REFERENCES

Alt, D. D.; Hyndman, D. W. Roadside geology of the northern Rockies. Missoula, MT: Mountain Press Publishing Company; 1972. 280 p.

Ballard, Warren B.; Miller, Sterling D.; Spraker, Ted H. Home range, daily movements, and reproductive biology of brown bear in south-central Alaska. The Canadian Field-Naturalist. 96(1): 1-5; 1982.

Bratton, G. E. Personal communication. Located at: Lake County Extension Office, Ronan, MT; 1985.

Borror, Donald J.; DeLong, Dwight M.; Triplehorn, Charles A. An introduction to the study of insects. 4th ed. New York: Holt, Rinehart, and Winston; 1976. 852 p.

Chapman, John A. Studies on summit frequenting insects in western Montana. Ecology. 35(1): 41-49; 1954.

Chapman, John A.; Romer, John I.; Stark, John. Ladybird and army cutworm adults as food for grizzly bears in Montana. Ecology. 36(1): 156-158; 1955.

Cheff, V. E., Sr. Personal communication. Located at: Charlo, MT; 1985.

Claar, James J.; Klaver, Robert W.; Servheen, Christopher W. Grizzly bear management on the Flathead Indian Reservation, Montana. In: Proceedings, international conference on bear research and management; [in press].

Craighead, John J.; Summer, J. S.; Scaggs, G. B. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Wildlife-Wildlands Institute Monograph 1. Missoula, MT: University of Montana, U of M Foundation; 1982. 279 p.

Confederated Salish and Kootenai Tribes. Mission Mountain Wilderness management plan. Pablo, MT: Confederated Salish and Kootenai Tribes, Wildland Recreation Department; 1982. 102 p.

Confederated Salish and Kootenai Tribes. Unpublished data. Located at: Wildland Recreational Department, Pablo, MT; 1985.

Confederated Salish and Kootenai Tribes; Bureau of Indian Affairs. Flathead Indian Reservation grizzly bear management plan. Ronan, MT; 1981. 119 p.

Cook, William C. Studies on the ecology of Montana cutworms (Phalaenidae): geographic distribution, seasonal succession and local distribution of moths as affected by cultivation in the "Nigger Hollow" area. Ecology. 8(2): 158-173; 1927.

Davis, W. M. The Mission Range, Montana. Geographic Review. 2: 267-288; 1916.

Edwards, Gordon. Entomology above timberline. II. The attraction of ladybird beetles to mountain tops. The Coleopterists' Bulletin. 11: 41-46; 1957.

Elrod, Morton J. [Unpublished paper describing a trip of Freeman Daughters, Shoemaker, and Watson]. No date a. 2 leaves. Located at: University of Montana Library, Morton J. Elrod collection, Missoula, MT.

Elrod, Morton J. A grizzly bear home. No date b. Unpublished paper on file at: University of Montana Library, Morton J. Elrod collection, Missoula, MT.

Fields, G. R.; McMullen, R. D. Aggregation sites and behavior of two species of Hippodamia (Coleoptera: Coccinellidae) in south-central British Columbia. Journal of the Entomological Society of British Columbia. 69(1972): 25-27; 1972.

Harper, A. M.; Lilly, C. E. Aggregations and winter survival in southern Alberta of Hippodamia quinquesignata (Coleoptera: Coccinellidae), a predator of the pea aphid (Homoptera: Aphididae). The Canadian Entomologist. 114(4): 303-309; 1982.

Harrison, Jack E.; Reynolds, Mitchell W.; Kleinkopf, M. Dean; Pattee, Eldon C. Mineral resources of the Mission Mountains Primitive Area, Missoula and Lake Counties, Montana. Bulletin 1261-B. Washington, DC: U.S. Department of the Interior, Geological Survey; 1969. 48 p.

Jensen, G. L. Personal communication. Located at: Cooperative Extension Service, Montana State University, Bozeman, MT; 1985.

Johnson, C. G. Migration and dispersal of insects by flight. London: Methuem and Company Limited; 1969. 763 p.

Jope, Katherine L. Implications of grizzly bear habituation to hikers. Wildlife Society Bulletin. 13(1): 32-37; 1985.

Kendall, K. C. Personal communication. Located at: Research Division, U.S. Department of the Interior, National Park Service, Glacier National Park, West Glacier, MT; 1985.

Kruck, Lonn. The impact of hunting on Idaho's Pasimeroi mountain goat herd. In: Samuel, William; Macgregor, W. G., eds. Proceedings of the first international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia, Ministry of Recreation and Conservation, Fish and Wildlife Branch; 1977: 114-125.

Maggnuson, W. E.; Caughley, G. J.; Grigg, G. C. A double estimate of population size from incomplete counts. Journal of Wildlife Management. 42(1): 174-176; 1978.

McArthur Jope, Katherine L. Habituation of grizzly bears to people: a hypothesis. International Conference on Bear Research and Management. 5: 322-327; 1983.

McArthur Jope, Katherine. Interactions between grizzly bears and hikers in Glacier National Park, Montana. Report 82-1. Corvallis, OR: Oregon State University, Cooperative Park Studies Unit; 1982. 62 p.

McCullough, Dale R. Behavior, bears, and humans. Wildlife Society Bulletin. 10(1): 27-33; 1982.

Pardee, J. T. Late Cenozoic block faulting in western Montana. Bulletin of the Geological Society of America. 61: 360-404; 1950.

Pepper, J. H. Observations on a unidirectional flight of army cutworm moths and their possible bearing on aestivation. The Canadian Entomologist. 64(11): 241-242; 1932.

Pfeiffer, E. W. [Letter to R. W. Klaver]. 1982 September 9. 1 leaf. Located at: U.S. Department of the Interior, Bureau of Indian Affairs, Flathead Agency, Pablo, MT.

Pruess, Kenneth P. Migration of the army cutworm, Chorizagrotis auxiliaris (Lepidoptera: Noctuidae). I. Evidence for a migration. Annals of the Entomological Society of America. 60(5): 910-920; 1967.

Rockwell, David B.; Hosford, Sharon; Marineau, Dawn Marie; Swift, Tim; Taylor, Finn. Mission Mountain Tribal Wilderness management proposal. Missoula, MT: University of Montana, School of Forestry, Wilderness Institute; 1978. 144 p.

Romer, John I. [Letter to R. W. Klaver]. 1982 October 4. 1 leaf. Located at: U.S. Department of the Interior, Bureau of Indian Affairs, Flathead Agency, Pablo, MT.

Russell, R. H.; Nolan, J. W.; Woody, N. G.; Anderson, G. H. A study of the grizzly bear in Jasper National Park 1975 to 1978. Edmonton, AB: Canadian Wildlife Service; 1979. 136 p.

Servheen, Christopher. Grizzly bear ecology and management in the Mission Mountains, Montana. Missoula, MT: University of Montana; 1981. 139 p. Ph.D. dissertation.

Servheen, Christopher. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. Journal of Wildlife Management. 47(4): 1026-1035; 1983.

Servheen, Christopher; Klaver, Robert. Grizzly bear dens and denning activity in the Mission and Rattlesnake Mountains, Montana. International Conference on Bear Research and Management. 5: 201-207; 1983.

Stockstad, Dwight. The mysterious Missions. Sports Outdoors. 1(2): 17-20, 30-31; 1959.

Walken, H. H. Cutworms, armyworms, and related species attacking cereal and forage crops in the central Great Plains. Circular 849. Washington, DC: U.S. Department of Agriculture; 1950. 52 p.

Wright, Phillip L. [Letter to R. W. Klaver]. 1982 September. 3 leaves. Located at: U.S. Department of the Interior, Bureau of Indian Affairs, Flathead Agency, Pablo, MT.

Underhill, Robert L. M.; Underhill, Miriam E. Climbs in the Montana Rockies. I. The Mission Range. Appalachia. 28: 145-167; 1950.

U.S. Department of the Interior, Bureau of Indian Affairs. Unpublished data. Located at: Wildlife Branch, Flathead Agency, Pablo, MT; 1985.

Session VI—Cumulative Effects

Chaired by:

James Claar, Supervisory Wildlife Biologist, Bureau of Indian Affairs, Flathead Agency, Pablo, MT

CUMULATIVE EFFECTS ANALYSIS: ORIGINS, ACCEPTANCE, AND VALUE TO GRIZZLY BEAR MANAGEMENT

Alan G. Christensen

ABSTRACT: The cumulative effects analysis process developed on the Kootenai National Forest was born of need generated by proposals for access and activity in critical grizzly bear habitat. It has been applied to the analysis of extremely controversial projects involving hard rock mineral exploration and has been the focus of conflict between rights granted in the 1872 Mining Law and responsibilities of Federal agencies under the Endangered Species Act of 1973. Despite suits and threats of suits from developmental and environmental interests, the process has been accepted and utilized by Forest Service land managers. This paper outlines the process and explores the application of cumulative effects analysis to Forest activities over the past 3 years and how that application has assisted in making sensitive land management decisions. It also suggests that analysis of land management activities has been permanently altered by applying a cumulative effects perspective.

INTRODUCTION

Cumulative effects analysis has received a great deal of attention in recent years. As applied on the Kootenai National Forest, the process assesses how human activities affect the environment in space and time and how those changes may influence grizzly bears.

The Kootenai process (Christensen and Madel 1982) involves the field identification of 13 distinct habitat components, the mapping of the extent and location of those components on topographical maps, and the development of "activity" overlays on Mylar. The process is somewhat labor-intensive and the process requires users to have a detailed knowledge of the geographical area and accurate information about the nature and timing of the activities proposed. Each working base map covers approximately 200 mi^2. Supporting data sheets detail the quantity, seasonal importance, and identity of the grizzly bear habitat components known to occur within the area. Mylar overlays depict road access and influence zones, land management activities, recreational and mineral activities, and other information determined to influence grizzly bear habitat.

The resulting combination provides managers with detailed grizzly habitat information in the form of base maps. These maps enable them to graphically display and measure how known activities will affect grizzly habitat in terms of space, time, food, and denning habitat. The process tracks and displays activities that potentially affect grizzly habitat by directly reducing available space and foods or by influencing the time and manner in which other related activities can be accomplished. Thus, although each activity taken independently may be relatively innocuous, the synergistic effect of several management actions may be significant. Ecologically and philosophically, cumulative effects analysis provides an opportunity to examine the whole picture while meeting day-to-day management needs.

BACKGROUND

Grizzly bears were declared a threatened species in 1975, at which time large corporate mineral interests had already conducted extensive prospecting and claiming of suspected copper-silver deposits in the Cabinet Mountains in northwestern Montana. Grizzly bears and the copper/silver-bearing Revett Formation inevitably were drawn together when the Kootenai National Forest delineated essential habitat in late 1977. Contained within the boundary of the essential habitat were claims and exploratory drill holes that had given evidence of important copper-silver deposits.

In the late 1970's, there was a paucity of information on grizzly bears or their habitat in the Cabinet Mountains. The Forest funded a study (Erickson 1978) to ascertain whether grizzlies still existed in the Cabinets and to provide some general information on habitat. About the same time, the Section 7 consultation requirements of the Endangered Species Act were implemented. As of May 1979, the Forest had never formally consulted on grizzly bear issues, so procedures and mechanisms were untested. At

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Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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that time, a proposal for a helicopter-supported exploratory drill operation in essential grizzly habitat inside the Cabinet Wilderness was submitted and analyzed. With little data on the grizzly bear or its habitat and no established procedure, the biological evaluation became a review of existing literature and a list of assumptions on how they related to the situation.

In 1980, the problem became considerably more complex when a proposal was submitted for a 3-year multihole exploratory drilling program in grizzly habitat. The biological evaluation focused on available foods, seasons of use, and assumptions about bear response to mechanized equipment. The evaluators were frustrated because, although other activities were already affecting grizzly bear habitat in and adjacent to the Cabinet Wilderness, there was no recognized procedure for effectively dealing with them or weighing their effects. The exploratory drilling permit was granted and appealed, and after denial of the appeal, a lawsuit was filed in Washington, DC by a coalition of environmental groups. The subsequent judgment supported the issuance of a permit to drill, but it became clear from this experience that a better method of analyzing activities in grizzly habitat was sorely needed.

That same year, Kootenai National Forest personnel began to describe and map grizzly bear habitat components. These food and denning components became the basic descriptions of grizzly habitat and ultimately provided the basis for development of a cumulative effects process.

In 1981, the Flathead National Forest, Glacier View District, published a cumulative effects process that consisted of displaying activities on a series of maps and overlays and coordinating activity schedules to minimize overlap and conflict. The process failed to quantify impacts, identify baseline habitat needs for grizzly bears, or draw conclusions on the condition of habitat before or after analysis. Despite its limitations, it was a valuable procedural step.

By 1982, the Kootenai National Forest had produced a cumulative effects analysis process (Christensen and Madel 1982) which built on the Flathead document. In contrast to the Flathead document, however, the Kootenai cumulative effects analysis process identifies and quantifies food and denning components, space, and the availability of habitat to grizzlies at any time.

DISCUSSION

Immediately upon completion, the cumulative effects process was applied to ongoing activities in the Cabinet Mountains. An area of approximately 500,000 acres was divided into eight distinct bear units for analysis. This area required 15 project maps and data on 72 drainages, the result of 2 years of field work. Simultaneously, the developers of the process put emphasis into explaining the process to the general public, various organizations and clubs, State and Federal agencies with grizzly management responsibilities, and the Kootenai National Forest management team. They also produced a brief video presentation for ranger districts and other Forests. The process met with enthusiastic and nearly universal acceptance, mainly because the process is a simple assemblage of relationships and not a complex model, even though it includes considerable detail. Nearly everyone could understand the basic elements involved (food and habitat security), was aware of the underlying ecological principles, and could comprehend the tangible array of information on maps and overlays. This accessibility facilitated its acceptance.

A National Forest is made up of separate districts, all of which have individual rangers who exercise a great deal of autonomy. Management style, personal philosophy, and work ethic influence how each ranger operates the district. In dealing with a resource which cuts across district boundaries and for which no universally accepted methodology of management exists, the differences between how districts deal with that resource can be significant, controversial, and disruptive. Because grizzly bears have a large home range size and the mobility to quickly move across administrative boundaries, proper management of their habitat necessitates cooperation among all involved. Before the development of cumulative effects analysis, individual districts and Forests had evolved independent methods for dealing with grizzly bears. One ranger might favor road management; another would not implement road closures. Adjacent districts used different coordination techniques, different contract language, and different management limitations. All of this was confusing to contractors and the general public and raised questions about which course of action was correct.

Coordination of in-house activities in the Forest Service is complex and makes it difficult to predict habitat conditions over time. Yet in-house activities are directed by various laws, policies, and regulations and are reviewed by the interdisciplinary process. When unscheduled demands from other agencies or individuals are superimposed on in-house activities, resource management becomes extremely complex, particularly for a species as mobile and controversial as grizzly bears.

Hard rock mineral exploration in the Cabinet Mountains is such an unscheduled demand. Based on rights granted by the Mining Law of 1872, individuals can claim, prospect, explore, and develop mineral deposits on public lands, even within Wilderness areas. Major mineral activity proposals cause a ripple effect through all Forest programs and create an air of unpredictability, which raises questions about the certainty of previously scheduled in-house

activities. It was into such an environment that the cumulative effects analysis process was initiated on the Kootenai National Forest in 1982. At that time circumstances surrounding a major hard rock mineral exploration effort were directly affecting two ranger districts with scheduled annual timber harvests of over 40 million board feet and established public use of the south half of the Cabinet Mountains. The situation had been tested in Federal court, was the subject of frequent consultation between U.S. Department of the Interior, Fish and Wildlife Service, and Kootenai National Forest personnel, and was closely scrutinized by many special interest groups.

APPLICATIONS

Public acceptance and feedback about the cumulative effects analysis process contributed significantly to management's acceptance and willingness to apply it. Early confidence and interagency support were important.

Application of the process forced the first complete inventory of all known planned activities within a given area on the Forest. Much like the process used on the Flathead, all activities were identified and maps and schedules were prepared. Estimates of public recreational activities within the area were based on historical use patterns. This information provided a checklist of activities over most of which the Forest Service had some discretionary control, an important point in the later identification of mitigation and compensation options.

Overlaying this information on habitat maps clearly protrayed the level of activity and how it affected grizzly bear habitat. Combining activity and habitat information permitted managers to determine for the first time what habitat was being affected, how scarce or abundant that habitat was, and what the cumulative effects of planned resource management decisions were.

The Forest Service cannot deny rights granted under the Mining Law of 1872 but can only influence how they are conducted. Therefore, in the cumulative effects perspective, statutory rights had to be accommodated; discretionary activities became the method by which space and components were freed up for compensation. With the cumulative effects process, managers could observe options and measure their effects on space and food components. The ability to quantify and weigh tradeoffs, to measure the effect of various decisions on grizzly habitat, and to observe the results enabled managers to control situations rather than react to them. Even though some options were distasteful, managers could choose a course of action with a clear idea of the tradeoffs. This capacity created high credibility for the cumulative effects process among managers. With increased confidence in the system came reassurance that administrative and litigative actions could be dealt with and that, rather than being reactive and defensive, managers were being proactive.

Not only did this confidence help managers deal with internal scheduling and decision making; it facilitated the coordination of permit requests with other activities. With the knowledge and perspective gained from cumulative effects analysis, managers were able to identify permit requirements, schedule demands, and identify the constraints necessary to protect important grizzly habitat while meeting other resource demands. Of equal importance, management could respond significantly faster once a cumulative effects analysis had been conducted. Options and constraints for that calendar year were quantified and highlighted so that new proposals could be quickly analyzed and firm responses could be made. An interesting circumstance developed when those who first applied for activity permits established a "first in time, first in right" stance. This perspective worked to the disadvantage of late applicants but did not constrain the Forest Service from providing for minerals exploration activity.

As experience with the system in land management increased, decisions were directly related to how space and food for grizzly bears would be affected, what seasons were best for activities to occur, and how close each bear unit approached threshold levels. In addition, by determining that ongoing activities were pushing the system to threshold levels, managers could foresee that additional activities would have to be rescheduled, modified, or wait until space and time became available.

Some aspects of the system had negative results. The process includes an assumed threshold that identifies the level of habitat effectiveness necessary to meet the needs of an adult female grizzly. Despite caveats about the reliability of the threshold, managers at times scheduled activities to use up all available space and time to threshold limits. At other times the threshold became a security point and managers were uncomfortable about finding conditions that were just below the quantified threshold and sought ways to get slightly above, even though biologically the changes were of no consequence. With the demands on public lands, the identification of threshold values can pose a risk in that the threshold may become the level at which a resource is managed. In that light, thresholds should be identified with caution.

As of 1985, the Kootenai will have been applying the cumulative effects analysis process to portions of the Forest for 4 consecutive years. Despite imperfections in the process and the use of extrapolated data, application of the process has substantially benefited grizzly habitat management and the process has become standard operating procedure. All districts now share a common management methodology and understand the need for shared information and tradeoffs.

Management credibility remains high, and legal action against Forest decisions has declined. Coordination with major corporate mineral interests has been simplified, and consistent use and reliance on the process has reduced the corporations' apprehension.

As a management tool, the cumulative effects analysis process on the Kootenai National Forest has been successful. As data from the ongoing Cabinets grizzly bear study are incorporated, the process will undoubtedly improve.

REFERENCES

Christensen, Alan; Madel, M. Cumulative effects analysis process-grizzly habitat component mapping. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1982. 60 p.

Erickson, Albert. Grizzly bear management in the Cabinet Mountains of western Montana. U.S. Department of Agriculture, Forest Service. Contract No. 262-46 report. 1978. 82 p. Unpublished report on file at Kootenai National Forest.

CUMULATIVE EFFECTS ANALYSIS OF GRIZZLY BEAR HABITAT ON THE LEWIS AND CLARK NATIONAL FOREST

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ABSTRACT: An interagency work group derived a cumulative effects analysis process tailored to a selected bear management unit and using grizzly bear data from ongoing studies along the Rocky Mountain Front. Analysis is done by constituent element within a bear management unit, and a scoring system is used to assess each human activity's contribution to cumulative effects. Patterns of bear use (radio locations and observations gathered by Rocky Mountain Front grizzly studies) were analyzed to determine three zones of habitat effectiveness (high, moderate, low), which are used to display the results of the cumulative effects analysis. Thresholds were designated. Radiotelementry data from the bear management unit gathered subsequent to the development of this cumulative effects analysis process have tended to verify the zones of habitat effectiveness determined with this analysis process.

INTRODUCTION

The primary purpose of an interagency work group formed in 1983 was to assess cumulative effects on grizzly bears (Ursus arctos) and gray wolves (Canis lupus) in the area of a proposed exploratory natural gas well on the Lewis and Clark National Forest. The group was composed of Keith Aune and Gary Olson, Montana Department of Fish, Wildlife and Parks; Wayne Elliott and Thomas A. Day, U.S. Department of the Interior, Bureau of Land Management; and Steve Solem and Lewis Young, Lewis and Clark National Forest. The group decided to develop an analysis using grizzly bear data available for the Rocky Mountain East Front that would apply along the entire Front.

As a first step, the interagency work group reviewed the process developed and implemented by the Kootenai National Forest (Christensen 1982). They decided the East Front situation differed enough from the Kootenai to make unmodified use of the Kootenai process unfeasible. Habitat component mapping, which is key to the Kootenai process, is not yet available for the East Front, and a great deal of bear data from the Front are available from ongoing grizzly studies that began in 1977.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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Two of the basic components of the Kootenai process, however, were considered useful: the bear management units and using adult females as the key population segment.

ANALYSIS PROCESS

Bear Management Units

All occupied habitat on the Rocky Mountain East Front between U.S. Highway 2 and U.S. Highway 200 was divided into six units (called bear management units or BMU's) using the following criteria:

1. Units will be based on the amount of effective habitat necessary for a given number of adult female grizzly bears (subpopulation goal).

2. Each unit must contain all the seasonally required habitats and space (constituent elements) in sufficient quantity to meet the subpopulation goal.

3. Spring constituent elements should be similar within each unit.

4. Each unit should fit general movement patterns observed for radio-collared grizzly bears. (The existing data bases fit each unit.)

5. Each unit should have a similar mountain orientation and topography that influences forage richness, movements, and travel corridors.

Resulting BMU's range in size from approximately 250 to 420 mi^2 (650 to 1 090 km^2).

Studies by the Interagency Wildlife Monitoring/Evaluation Program indicate that in the core study area the grizzly population is healthy, stable, and at or near carrying capacity considering the limitations on capacity by current land uses and human activities (Aune and Stivers 1982; Aune and Stivers 1983; Aune 1983). Seven adult females occupy the core study area (Aune 1983), which is nearly the same in size and location as two BMU's combined (Birch-Teton and Teton-Sun River). The density of adult females in these two BMU's, then, is 1/97.4 mi^2 (1/252 km^2).

Extrapolating this density to the other BMU's provides an estimate of biological potential for adult females:

Badger-Two Medicine	4.1
North Fork Sun River	2.6
South Fork Sun-Beaver-Willow	4.3
Dearborn-Elk-Falls	3.0

Constituent Element Mapping

Constituent element maps of the Lewis and Clark National Forest were developed in cooperation with Keith Aune, Montana Department of Fish, Wildlife and Parks, by mapping landtypes (Holdorf 1981) that had been used by radio-collared grizzlies (Aune and Stivers 1982). Landtypes used for denning were at elevations above 6400 ft (1 952 m) in accordance with observed den site elevations (Aune and Stivers 1983).

Baseline Activities

Various human activities take place annually and form a baseline from which to evaluate cumulative effects. Each activity and the area it influences directly or indirectly (influence zone) is mapped (fig. 1). Influence zones are based on research data from East Front grizzly studies, literature, and professional opinions of bear biologists. Baseline activity definitions are in the appendix.

An influence zone of 1 km (0.6 mi) was mapped around each road open to four-wheeled vehicles based on East Front grizzly studies (Aune and Stivers 1983). An influence zone of 1 km (0.6 mi) was also mapped around oil and gas drill site locations (Harding and Nagy 1980).

Trails, snowmobile routes, timber activities, campgrounds, trailheads, and administrative sites all were mapped with 0.5 mi (0.8 km) influence zones. Chester (1976) recorded the flight of bears whenever humans were detected at distances up to 0.5 mi (0.8 km), and humans are involved in all of the previously mentioned activities. Grazing, private land, and hunting activities were mapped only in the area involved.

The matrix used to derive the effect scores (table 1) displays the baseline activities on the left side. We recognized that several of the baseline activity categories should eventually be refined by further subdividing some of the categories (for example, dividing roads into high or low use), but initially the activities were kept as simple as possible.

Scoring System

The cumulative effects analysis is done by BMU by constituent element; a scoring system is used to assess each activity's contribution to cumulative effects. Each activity is evaluated for six potential effects and displayed in a matrix format (table 1).

Potential effects of human activities are displayed along the top of table 1. The work group assigned the numbers 1 to 6 to the effects based on the group's collective opinion as to the relative severity of each effect, with 6 being the most severe. Permanent loss of habitat was judged more severe in the long run than the death of a bear. Lack of management potential was judged equal to reduced forage because having the ability to manage can strongly influence the other effects. Reduced cover was judged less severe than reduced forage because bears will feed in areas well away from cover if they are not disturbed. Displacement was judged least severe of the six effects because the basic assumption was that bears have an area of equally effective habitat into which they can move. For each activity, an X is placed in the appropriate column if the effect is applicable. The numbers applicable for each checked effect are added to derive the effect score for each activity.

Activity duration is a factor in describing the impact; therefore, the duration (in months) of each activity is multiplied by the effect score (from table 1) to arrive at an impact score (table 2). The effect of overlapping human activities is additive; therefore, the impact scores associated with human activities (as mapped in fig. 1) are totaled to derive a cumulative effects score (fig. 2).

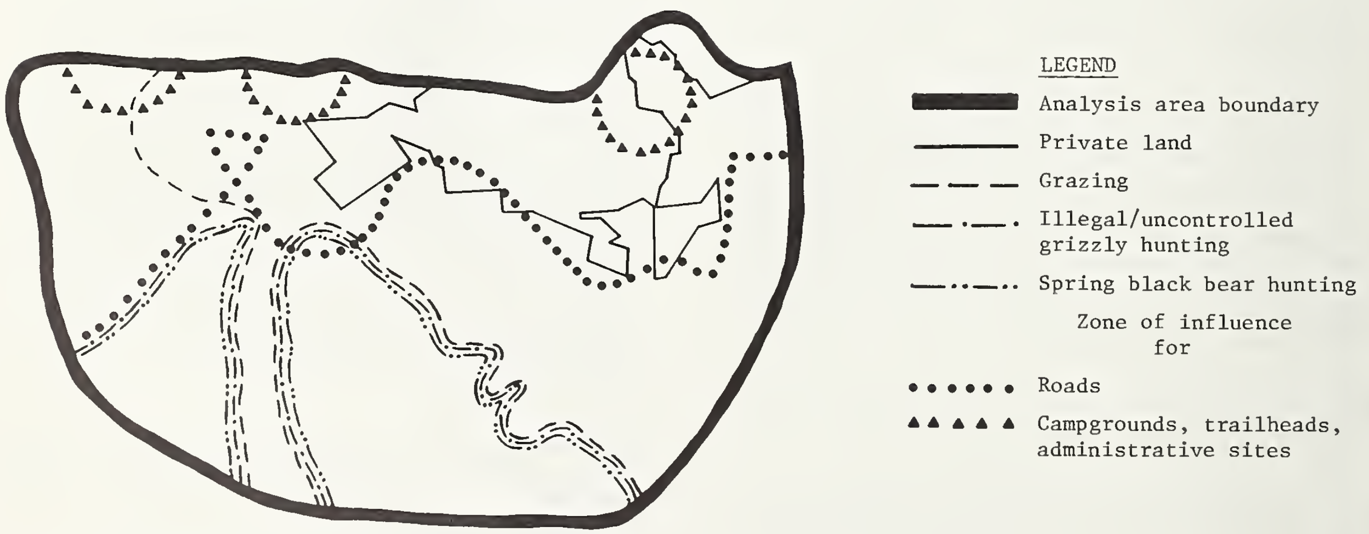

Figure 1.--Example of human activities in spring.

Table 1.--Effect scores by activity[1]

Activities	Permanent loss of habitat (6)	Direct mortality (5)	Lack of management potential (4)	Reduction in forage (4)	Reduction in cover (3)	Displacement (1)	Effect score
Hunting							
Illegal/uncontrolled		X	X			X	10
Legal		X				X	6
Grazing		X		X	X	X	13
Roads	X	X		X	X	X	19
Private land	X	X	X	X	X	X	23
Timber				X	X	X	8
Trails						X	1
Summer homes, administrative sites, campgrounds, trailheads	X	X		X	X	X	19
Snowmobiling					X	X	4

[1]See text for explanation of scoring.

Visual Display

A color scheme facilitates the visual display of the cumulative effects analysis. Three color zones are used to subjectively describe habitat effectiveness.

Green.--High habitat effectiveness. Human activities are at a level that generally allows grizzlies to make full use of the habitat.

Yellow.--Moderate habitat effectiveness. Human activities are at a level that reduces habitat effectiveness, but grizzlies are able to make some use of the habitat. The cumulative effects level is nearing the red zone.

Red.--Low habitat effectiveness. Human activities are at a level that permits only limited grizzly use of the habitat; however, red zones are still occupied habitat. A red zone generally indicates a "may effect" situation, which is defined as one having an apparent direct or indirect effect on the conservation and recovery of a listed species. The determination of "no effect" or "may effect" is an integral part of the consultation process between Federal agencies and the U.S. Fish and Wildlife Service under the Endangered Species Act.

Table 2.--Activity impact scores for concentrated use spring range

Activity	Effect score	X	Duration	=	Impact score
Illegal/uncontrolled grizzly hunting	10		3		30
Legal black bear hunting	6		3		18
Grazing on forest	13		1		13
Grazing off forest	13		3		39
Private land	23		3		69
Roads	19		3		57
Campgrounds, trail-heads, admin. sites					
Summit area	19		2		38
Cow camp, Hwy.2 trailhead, Paloo-kaville, Badger	19		1		19

Threshold Determination

Once the cumulative effects scores were mapped, the work group was faced with determining a threshold value for each of the habitat effectiveness (color) zones. Because of the data available from East Front studies, the group decided to use, to the extent possible, grizzly use patterns to indicate what areas were providing habitat.

For spring and summer/fall constituent elements, they compared the cumulative effects score map with grizzly observation and radio-relocation data collected from 1977 to 1983 by East Front grizzly studies in the Badger-Two Medicine BMU. A breakpoint between red and the other zones was determined first. If a pattern of use appeared in an area, it was judged to be providing effective habitat. A cumulative effect score that was representative of the break between those areas with a use pattern and those areas with little or no use was selected as the threshold between the yellow and red zones. The threshold between the green and yellow zones was determined in a similar manner by comparing use patterns with the cumulative effects scores and selecting a score that represented the break between areas of moderate and higher use. For the denning constituent element, thresholds were based

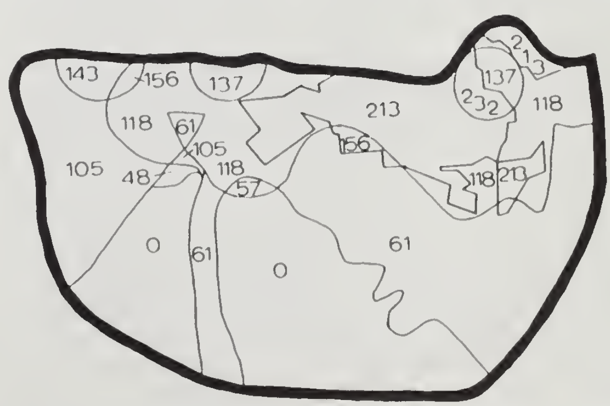

Figure 2.--Example of cumulative effect scores for spring.

on information derived from grizzly denning data from East Front studies (Aune and Stivers 1983; Schallenberger and Jonkel 1979) and other literature (Harding and Nagy 1980) that indicate bears are sensitive to disturbance both during den selection and while in the den and thus select remote, inaccessible denning sites.

Next it was necessary to determine the amount of area required by constituent element to maintain a target population. The best data on seasonal home ranges and densities are available from the core study area of the East Front grizzly study. Spring home range sizes are available for adult female grizzlies on the core study area, but concentrated use spring range has not been mapped off the National Forest. Therefore, a density figure for concentrated use spring range cannot be calculated yet. Density is believed to be the appropriate measure to use since it accounts for the overlap of home ranges.

Considering the foregoing, minimum space requirements on the spring consitituent element were derived as follows: The density of adult female grizzlies on the core study BMU's (where the population appears to be healthy, stable, and at or near carrying capacity) is 1 per 97.4 mi^2 (1/252 km^2). When extrapolated to the Badger-Two Medicine BMU (398.1 mi^2, or 1 031 km^2), this density results in a potential population of 4.1 adult females. If those 4.1 females were using the 133 mi^2 (345 km^2) of concentrated use spring range at the same time, the resulting density would be one adult female per 32.4 mi^2 (84 km^2), an area that is then used as the minimum space required to maintain each adult female grizzly on concentrated use spring range.

In the summer/fall constituent element, 97.4 mi^2 (252 km^2) is used as the minimum space required to maintain each adult female. This is the density of adult females from the core study area BMU's, and the entire area within all BMU's is considered summer/fall habitat.

Determination of Effect

The analysis process allows the determination of "may effect" in either of two ways. First, if the cumulative effects of baseline plus proposed activities significantly decrease habitat effectiveness (that is, color zones change from green to yellow to red), then a "may effect" situation exists. When an activity is proposed, an effect score and impact score are determined as in tables 1 and 2. The impact score is added to the cumulative effects score from baseline activities, and the new cumulative effects score is compared to the thresholds for color zones to see if the proposed activity changes the color zone. The analysis process also permits the evaluation of baseline activities to determine what options are available in the form of adjusting baseline activities to accommodate proposed activities when in combination they exceed threshold values for cumulative effects

The second way relates to population and space more directly. Derivation of the minimum space requirements for a target population of adult females has been described under Threshold Determination. If the cumulative effects analysis determines that the amount of green and yellow color zones is at or less than the minimum required to maintain a target population, then a "may effect" situation exists.

APPLICATION, VERIFICATION, AND FUTURE CONSIDERATIONS

This cumulative effects analysis process was applied to a controversial proposal to drill an exploratory natural gas well on the Lewis and Clark National Forest in the South Fork Two Medicine River drainage. The process was accepted by the U.S. Fish and Wildlife Service as an acceptable method of analyzing cumulative effects. Radiotelemetry data gathered subsequent to the development of this analysis process have tended to verify the zones of habitat effectiveness determined with this analysis process.

At the time this process was developed and applied, the work group realized that further refinement was possible and desirable and that the greatest refinement would result from applying the process to the BMU's with the greatest amount of bear data (Birch-Teton and Teton-Sun River BMU's). Nevertheless, the Lewis and Clark National Forest has ceased work on this analysis process and is pursuing the latest generation of cumulative effects analysis (cartographic modeling) for several reasons. It quickly became obvious that the manual system of overlay analysis was both labor and time intensive and did not easily lend itself to rapid updating of data or rapid analysis of proposed activities and alternatives. The Forest Service is thus pursuing an interagency effort to develop a cumulative effects model for all ecosystems that uses the basic model developed for the Greater Yellowstone Ecosystem (GYE). This model includes a habitat quality factor that was absent from the Lewis and Clark analysis process, and the GYE model is designed for computer application through cartographic modeling.

REFERENCES

Aune, Keith. [Personal communication.] Choteau, MT: Montana Department of Fish, Wildlife and Parks; 1983.

Aune, Keith; Stivers, Tom. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1982. 143 p.

Aune, Keith; Stivers, Tom. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department of Fish, Wildlife and Parks; 1983. 180 p.

Chester, J.M. Human wildlife interactions in the Gallatin Range, Yellowstone National Park, 1973-1974. Bozeman, MT: Montana State University; 1976. 114 p. M.S. thesis.

Christensen, Alan G.; Madel, Michael J. Cumulative effects analysis process/grizzly habitat component mapping. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1982. 38 p.

Elgmork, K. Human impact on a bear population (Ursus arctos L.). England Biol. Conserv. 13:81-103. 1978. [Not seen. Quoted in Schallenberger and Jonkel 1979.]

Harding, Lee; Nagy, John A. Responses of grizzly bears to hydrocarbon exploration on Richards Island, Northwest Territories, Canada. In: Martinka, Clifford J.; McArthur, Katherine L., eds. Bears--their biology and management: papers of the fourth international conference on bear research and management; February 1977; Kalispell, MT. U.S. Government Printing Office: Bear Biology Association; 1980: 277-280.

Holdorf, H.D. Soil resource inventory--Lewis and Clark National Forest. Great Falls, MT: U.S. Department of Agriculture, Forest Service, Lewis and Clark National Forest; 1981. 70 p.

Jonkel, Charles. Grizzly bears and livestock. Western Wildlands. 6(4): 11-14; 1980.

Shallenberger, A.; Jonkel, C.J. Rocky Mountain East Front grizzly studies, 1979. Special Report No. 27. Missoula, MT: University of Montana, School of Forestry, Border Grizzly Project; 1979. 115 p.

Zager, Peter Edward. The influence of logging and wildfire on grizzly bear habitat in northwestern Montana. Missoula, MT: University of Montana; 1980. 131 p. Ph.D. dissertation.

APPENDIX: BASELINE ACTIVITY DEFINITIONS

Legal hunting.--Hunting for game species in accordance with Montana Department of Fish, Wildlife and Parks regulations. Mortality results from hunting and some displacement occurs due to bears avoiding hunters (Aune 1983).

Illegal/uncontrolled hunting.--Illegal hunting is that which occurs inside the National Forest boundary but is not in accordance with Montana Department of Fish, Wildlife and Parks regulations. Uncontrolled hunting is that which takes place on the Blackfeet Indian Reservation. Effects are similar to legal hunting, but the potential for management is lower.

Grazing.--Includes all aspects associated with livestock allotments of domestic sheep and cattle or horses. Several mortalities have been associated with livestock grazing along the Front (Aune and Stivers 1983). Livestock grazing, especially in riparian/aspen areas, reduces available forage and cover (Jonkel 1980), and some bears appear to be displaced by grazing and associated activities like herding or salting (Aune 1983).

Roads.--All travelways open to the use of four-wheeled vehicles are included. Roads cause physical loss of habitat as well as reduce the availability of forage and cover because bears tend to avoid roads (Aune and Stivers 1982; Elgmork 1978). Road access increases the vulnerability of bears to direct mortality.

Private land.--For the Badger-Two Medicine BMU, this includes all the Blackfeet Indian Reservation and private lands within the National Forest boundary. State and Federal agencies concerned with grizzly bear management have little or no control over bear management, especially habitat management, on private lands. Direct mortalities often result from conflicts on private lands. Permanent habitat losses occur through building construction and conversion of good habitats like riparian areas to hayfields or other crops. Grazing and crop production reduce forage and cover, and human activities can displace bears.

Timber.--All aspects of timber management and harvest are included (for example, timber sales, post and pole sales, planting, thinning, firewood gathering). The roads associated with most timber activities are rated separately. Forage and cover are reduced by timber activities, at least for the short term, and displacement occurs as well (Zager 1980).

Trails.--Those travelways open to travel by foot, horse, or motor vehicles less than 40 inches (102 cm) wide. Only those trails receiving higher levels of use are included. The habitat effectiveness of an area traversed by a trail is reduced when some level of activity (use) is reached because of displacement. Chester (1976) documented bear displacement along trails due to encounters with people; Schallenberger and Jonkel (1979) discuss some relationships between trails and grizzlies.

Summer homes, administrative sites, campgrounds, trailheads.--Because of human occupation, the potential for direct mortality exists. The structures and facilities required for this category of activity permanently destroy habitat. Forage and cover may be reduced because of recreational livestock grazing around these sites as well as being unavailable due to displacement from human activities around these sites. Schallenberger and Jonkel (1979) discuss the relationships of bears to these sites.

Snowmobiling.--The use of over-the-snow machines has the potential to displace animals and reduce the effectiveness of cover along traveled routes.

DERIVATION OF HABITAT COMPONENT VALUES FOR THE YELLOWSTONE GRIZZLY BEAR

David J. Mattson, Richard R. Knight, and Bonnie M. Blanchard

ABSTRACT: Methodology is described by which values, as coefficients, were derived for grizzly bear habitat components in the greater Yellowstone area. The specific algorithm incorporates measures of diet item value, relative frequency of diet item consumption, preference for diet item consumption, diversity of feeding activity or opportunity, and seasonal adjustment in calculation of each habitat component coefficient. Methodology is also described by which number of feed sites can be estimated and further allocated among habitat components for diet items that are grazed and whose use is not discernible by feed site analysis.

INTRODUCTION

Quantitative habitat evaluation, risk analysis (Salwasser and others, in press), and, most recently, cumulative effects analysis (Christensen 1982; Weaver and others this volume) are being used for increasingly sophisticated grizzly bear habitat management. All these techniques require some numeric evaluation of map units, whether individual habitat components or extensive bear management units.

Other studies in the Northern Rocky Mountains have derived numeric values for grizzly bear habitat components (Mealey and others 1977; Christensen 1982; Craighead and others 1982; Mace 1984), and all have based their numeric evaluations primarily on known vegetal diet items in various map units, typically habitat components. Random or stratified-random sampling was used to enumerate representative diet items. In two studies (Craighead and others 1982; Mace 1984), representation of diet items was weighted by the relative food value or preference assigned to them.

Additional research has explored grizzly bear habitat preference (Zager 1980; Aune and Stivers 1981; Servheen 1983; Knight and others 1984) but has not transformed this information into relative numeric habitat valuation. In any case, studies employing use-availability analyses (Neu and others 1974; Marcum and Loftsgaarden 1980) generate empirical results that are often difficult to interpret and that may have limited extrapolability (Knight and others 1984).

The Interagency Grizzly Bear Study Team (IGBST) also developed a method for deriving habitat component values, one that is conceptually more sophisticated then previous approaches. The methodology used an extensive data base derived from scat and community site analysis collected over a 7-year period, 1977-83, in association with radio-telemetry sampling of grizzly bear habitat use. The Team also used digitized map data for Yellowstone National Park provided by D. Despain. This approach was conceptual and thus allowed flexibility and extrapolability in using derived coefficients. The methodology was also compatible with the cumulative effects analysis model developed for the greater Yellowstone area (Weaver and others this volume). This paper presents the logic and details of the IGBST approach.

METHODS

Food habit and habitat data used for generating habitat component coefficients were collected by the IGBST as part of followup to aerial radio-telemetry location of collared grizzly bears. Scats were collected for analysis and comprehensive field forms were completed; habitat type, cover type, and feeding activity were identified. Mapping of the greater Yellowstone area is being completed using standard habitat and cover types also employed in IGBST analysis of grizzly habitat use. Blanchard (1985) discusses in more detail methods pertinent to collecting data used for generating habitat component coefficients. Mattson and Despain (1985) discuss methods pertinent to the mapping and digitizing of cover and habitat types in Yellowstone National Park.

RESULTS

Our methodology for deriving habitat component coefficients delineated a variety of spatial and temporal strata. In applying the technique, however, we were conceptually limited regarding habitat components, that is, relatively homogeneous, abstract topographic-vegetation

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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habitat units that recur over the landscape and are identifiable by specific criteria. We used as habitat components, and thus calculated values on a seasonal basis (spring, summer, and fall) for, individual forest and nonforest habitat and community types (Pfister and others 1977; Mueggler and Stewart 1980; Gregory 1983; Steele and others 1983; Mattson 1984).

The Team used four data sets in model development and calculations: (1) frequency and volume scat data stratified by taxonomically identifiable diet items and by date; (2) community site analyses stratified by feeding activity types, habitat components, and date; (3) unit area food values, stratified by date, associated with diet items extracted by characteristic feeding activities; and (4) summary statistics for habitat component area in Yellowstone National Park. Unit area food values (data set 3 above) integrated measures of per-bite energetic efficiency, exclusivity of use, nutritive value, landscape search efficiency, and year-to-year fluctuation in use/availability (Mattson and others in preparation).

In calculating unit area habitat component value (UHV'_{jk}), we integrated five basic factors (fig. 1): (1) unit area food value (UFV_{ik}) associated with each feeding activity/feed site type, by season; (2) proportionate representation of feeding activity types (X_{ijk}) relative to all community site analyses recorded, including those without evident feeding activity, by habitat component and season; (3) preference or relative feed site density (APF_{ijk}) recorded for each habitat component, by feeding activity type and season; (4) diversity of recorded feeding activity (DI_{jk}), by habitat component and season; and (5) an adjustment factor (F_k) reflecting seasonally disparate numbers of utilized habitat components:

$$UHV'_{jk} = ((\sum_{j=1} UFV_{ik} * X_{ijk} * APF_{ijk}) * DI_{jk} * F_k)/UHV_{jk\,max} \quad (1)$$

Value attributable to a habitat component was thus partitioned among these various factors.

Each feed site or feeding activity type was imparted the value (UFV_{ik}) of the associated extracted diet item. This imparted value was further weighted by relative preference or feed site density (APF_{ijk}) recorded for each feeding activity in each habitat component. Feed sites of the same type were accorded equal value but occurred, because of grizzly preference or site availability, with varying unit area frequency (density) in habitat components. Therefore, UFV_{ik} was multiplicatively weighted by APF_{ijk} to adjust for difference feed site type densities.

Feed site density or preference (PF_{ijk}) was the quotient, by component, of proportionate feed site distribution among habitat components (Y_{ijk}) divided by either proportionate area availability of each component (P_j) or proportionate distribution of all community site analyses, whether feed site or not, among components (Y_{jk}). Use of P_j or Y_{jk} depended on philosophical or conceptual point of view as well as scale of reference. PF_{ijk} was adjusted by natural logarithmic transformations to account for sensitivity of the quotient to small per-type sample size and representation. Natural log transformations were applied for $Y_{jk} \leq 0.25$, untransformed quotients used for $Y_{jk} > 0.75$, and an average of log transformed and untransformed values employed for $Y_{jk} > 0.25$ and ≤ 0.75. APF_{jk} resulted from scaling PF_{ijk} for each feeding activity type from 0.00 to 1.00 among habitat components.

The contribution of each feeding activity type to total habitat component value was a linear function of the proportionate representation of each feeding activity (X_{ijk}), as feed sites, in each habitat component. Thus, the product of $UFV_{ik} * APF_{ijk}$ for each feeding activity type was further adjusted by multiplication of X_{ijk}. A preliminary score (PS_{jk}) for each habitat component resulted from summation of the products for each feeding activity:

$$PS_{jk} = \sum_{i=1} (UFV_{ik} * X_{ijk} * APF_{ijk}) \quad (2)$$

PS_{jk} ranged in value from 0.00 to 1.00. At this point in the calculations no differentiation was made between components with only one potential feeding activity and other components with several.

Greater diversity of feeding activity or opportunity was logically considered to enhance the value of a habitat component. The probability of feeding opportunity, within an analysis time frame, was considered to be greater in those types with greater feed site diversity, especially given the large year-to-year fluctuations in diet item use and availability in the greater Yellowstone area (Picton and others this volume) and the correspondence of feed sites and clumped diet item populations within the matrix of a habitat component. Shannon-Weiner H' (Shannon and Weaver 1963; $H' = -\Sigma X_{ijk} \ln X_{ijk}$), constrained to minimum and maximum values of 0.333 and 1.000, was employed to approximate the effect of feeding activity/opportunity diversity (DI_{jk}) on habitat component value:

$$DI_{jk} = ((0.667/H'_{jk\,max})H'_{jk}) + 0.333 \quad (3)$$

The effect was assumed to be linear, although likely to be shown later as curvilinear, and so PS_{jk} was multiplied by DI_{jk}.

Further adjustment of calculated habitat value reflected seasonally disparate grizzly bear use of the total landscape. Greater value was assumed to be associated with components used during spring and fall when a fraction of available components provided food. This greater value was in contrast to summer, when nearly all components were available and producing some amount of food. In other words, during spring

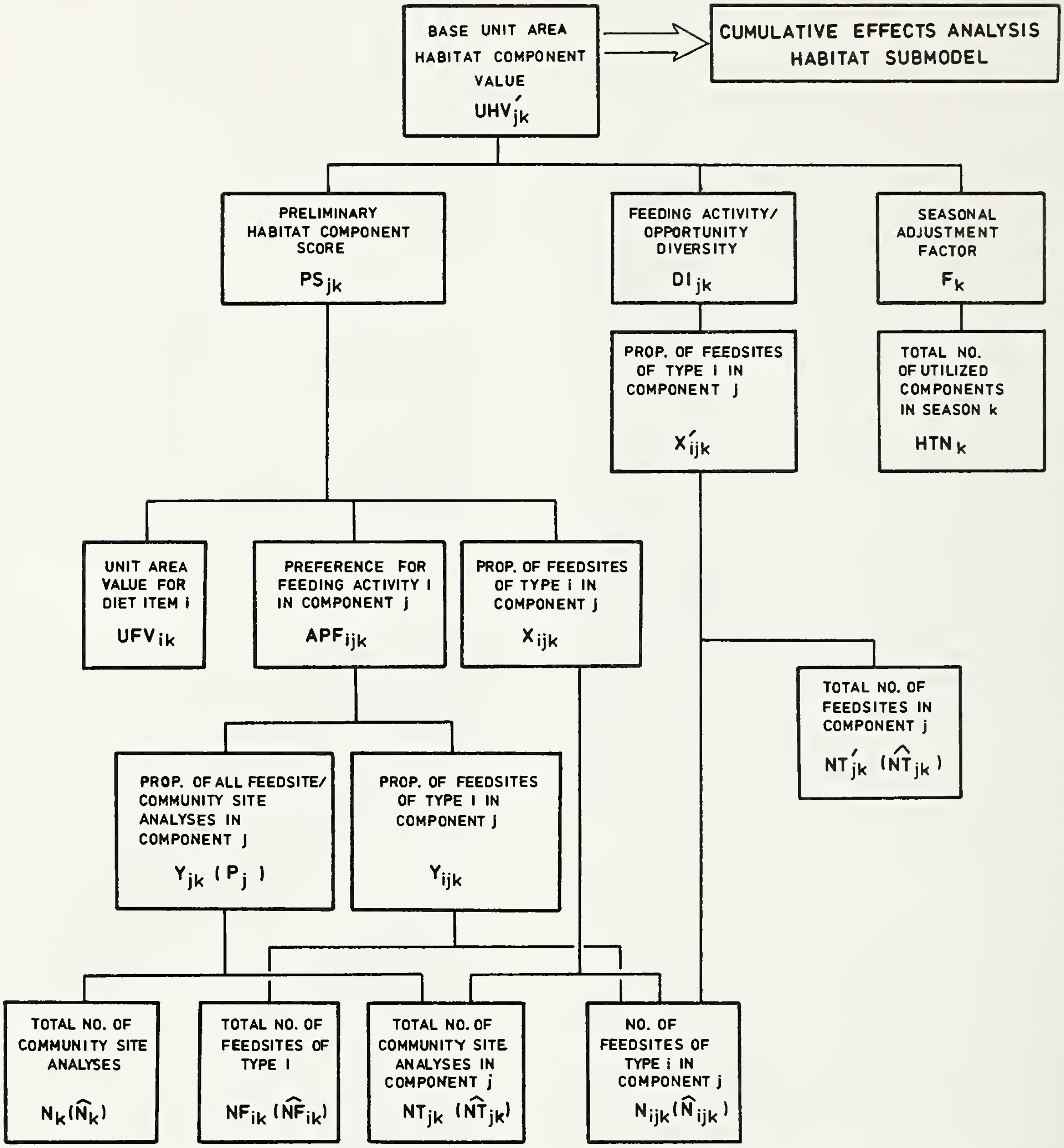

Figure 1.--Model diagram for calculation of base unit area habitat component value (UHV'_{jk}).

and, to a lesser extent, fall, landscape value (feeding activity) was concentrated in many fewer components than during summer. To facilitate comparison of habitat component seasonal values, factors (F_k) were applied to spring and fall values in inverse proportion to the number of components used. This interpretation of habitat value was considered to be sensitive to management dealing with seasonal scheduling of human activities. A habitat component used during both spring and summer and which produced cover and food of ostensibly equal value during both seasons was, by our logic, actually more valuable or sensitive to disturbance during spring.

Each component unit area value (UHV_{jk}) was divided by maximum UHV_{jk} to scale values of the resulting $UH\acute{V}_{jk}$ from 0.000 to 1.000. Scaled unit area coefficients ($UH\acute{V}_{jk}$) applied to habitat components in the Yellowstone ecosystem (sic) cumulative effects analysis process were standardized to maximum UHV_{jk} across all strata, by season and by presence of ungulate concentrations (Weaver and others this volume).

One difficulty was encountered in calculating unit area habitat component values ($UH\acute{V}_{jk}$). Feed site data were essentially nonexistent for grazed diet items; with the exception of thistle *(Cirsium scariosum)*, most grizzly bear grazing activity was not distinguishable from that of ungulates. Bear use of grazed diet items was, however, adequately documented by scat analysis, as was grizzly bear habitat occupancy by community site analyses associated with radiotelemetry sampling. From these data, grizzly bear grazing activity, as number of feed sites, could be estimated for each habitat component.

Two steps were required before numbers of feed sites could be estimated for each grazed diet item in each habitat component. First, a general relationship had to be developed between number of feed sites and unit scat frequency for those diet items extracted by bears in a manner (that is, by digging or some definitive manipulation) that allowed confident discernment at feed site-community site analyses. This relationship approached being a constant, $\widehat{NFFQ}$. Scat frequency, by diet item, was used to estimate $\widehat{NFFQ}$ because frequency was theorized to better correspond with feed site numbers. Scat volume reflected per-feed site diet item density as much or more than number of feed sites.

Using scat frequency data (FQS_{ik}) and estimated per-unit scat frequency feed site number ($\widehat{NFFQ}$), a total feed site number was calculated ($\widehat{NF}_{ik}$) for each grazed diet item. The next step required allocation of these feed sites among available habitat components.

Allocation of feed sites ($\widehat{NF}_{ik}$) among habitat components was based on allocation scores (AS_{ijk}) calculated for each component for each grazed diet item by season (fig. 2);

$$\hat{N}_{ijk} = \widehat{NF}_{ik} \; (AS_{ijk} / \sum_{j=1} AS_{ijk}) \tag{4}$$

Allocation scores were, in turn, based on three factors: (1) the correspondence, or fidelity, between ranked diet item use frequency distribution, as estimated by scat analysis, and ranked habitat component use frequency distribution, as estimated by community site analysis, by month ($FIK_{i\acute{j}k}$); (2) the total number of community site analyses recorded for each habitat component ($NT_{\acute{j}k}$); and (3) the mean abundance of diet items in each habitat component ($FQ_{i\acute{j}}$), as estimated by community site analyses:

$$AS_{ijk} = F\acute{Q}_{ij} * N\acute{T}_{jk} * AFID_{ijk} \tag{5}$$

Relative number of community site analyses by component ($NT_{\acute{j}k}$), scaled to values ranging from 0.00 to 1.00, and the correspondingly scaled mean abundance of diet item by component ($FQ_{i\acute{j}}$), when multiplied together, yielded a probabalistic measure of feeding activity occurrence by component and diet item. Investigation of habitat component use associated with reliably discerned feeding activity indicated, however, that component use was not a strict function of diet item abundance and frequency of habitat component occupancy. Area-wide and temporal patterns of food use and availability to a significant extent subsumed use of individual diet items in individual components. This other source of variation was more or less accounted for by assessing the fidelity in frequency distribution across months for habitat component and diet item use ($AFID_{ijk}$).

$AFID_{ijk}$ resulted from inverting and rescaling a measure of fidelity ($AFID_{ijk}$):

$$AFID_{ijk} = 1 - (FID_{ijk}/NM_{ik} - 1) \tag{6}$$

FID_{ijk} was the average difference between ranked use frequency, by month, for each component and diet item during a specified time frame (NM_{ik}):

$$FID_{ijk} = \sum_{m=1} \left[RS_{imk} - R_{jmk}\right])/NM_{ik} \tag{7}$$

As correspondence or fidelity in distribution of component and diet item was increased, FID_{ijk} linearly decreased.

DISCUSSION

We consider a habitat component to be any relatively homogeneous, abstract topographic-vegetation habitat unit that recurs over the landscape and is identifiable by specific criteria. The methodology described here for deriving habitat value is appropriate only when used to evaluate habitat components. This approach is conceptually invalid if applied to specific microsites or large-scale mapped areas such as grizzly bear management units or subunits. Weaver and others (this volume) describe how values generated by this methodology are incorporated in calculations of habitat value for large areas. An additional set of determinant factors are operable when extensive mapped areas are evaluated.

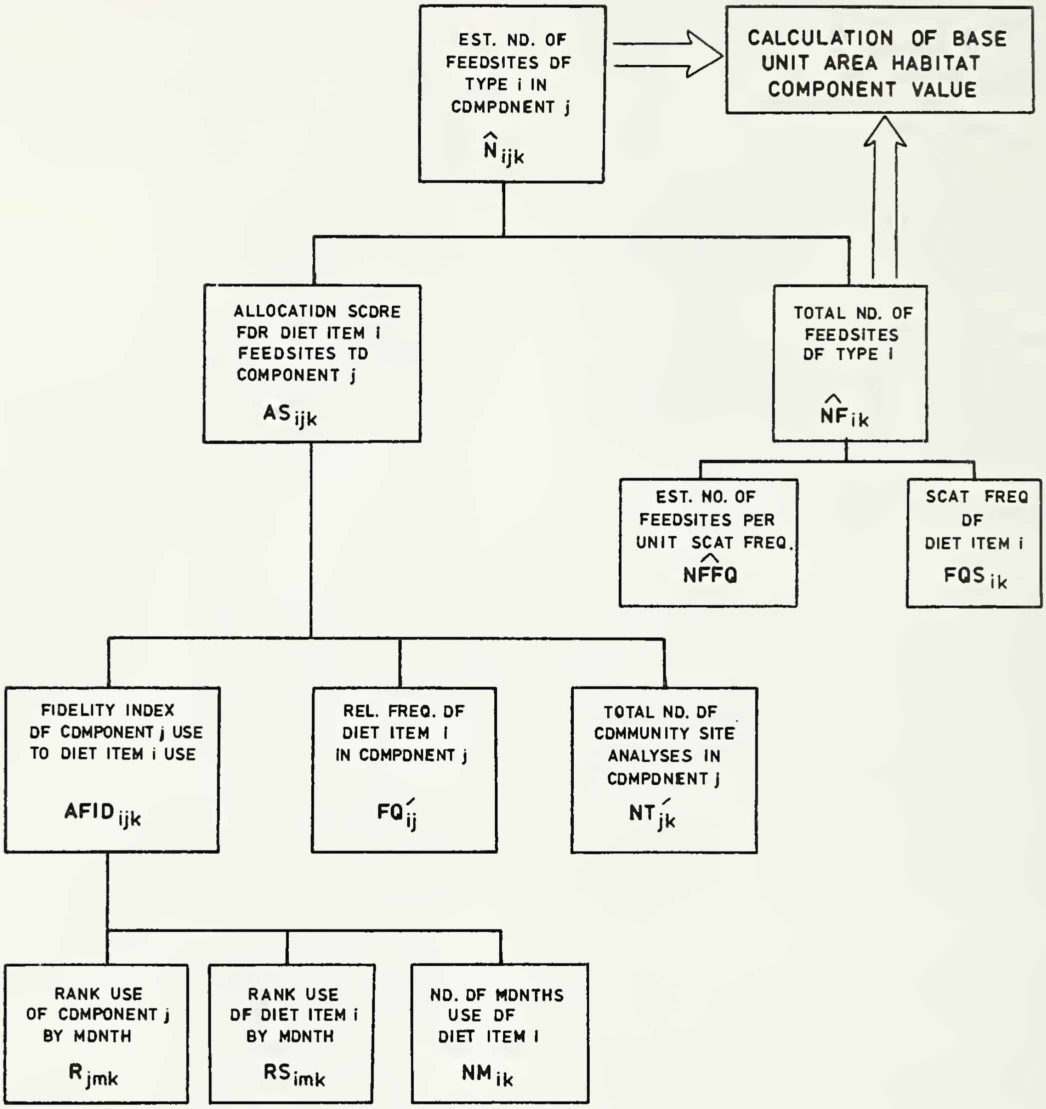

Figure 2.--Model diagram for estimation and allocation of feed sites ($\hat{N}_{ijk}$) among habitat components.

Our approach to generating base unit area habitat component value has several advantages. Foremost is the inherent flexibility lacking in results of use-availability analysis or empirical modeling. Using the methodology described in this paper, new habitat component values can be generated as components are redefined, data sets enlarged or restructured, analysis time frames readjusted, and foraging environments simulated (Picton and others this volume). This can all be achieved by manipulating the data sets integral to calculation of habitat values. A conceptual modeling approach also helps clarify relationships and contributing factors as well as identify research areas where data are scanty or totally lacking.

Most relationships in this model are linear; however, researchers have elucidated as many nonlinear as linear ecologic relationships (Hall and Day 1977). So, in the absence of more specific research and data, we have assumed linearity while expecting to later revise relationships in the model. In any case, the methodology described in this paper is faithful to our current state of knowledge concerning the grizzly bear and uses the most extensive data base available for any grizzly bear population. Logically derived and conceptually sound habitat component values will be available to ongoing management.

Wherever possible, habitat component coefficients generated by this methodology have been and will be tested. In general, despite its limitations and requirements for astute interpretation, use-availability analysis is the best standard by which conceptually derived unit area component values are judged. Results of such analyses in the greater Yellowstone area (Knight and others 1984) substantially conform with coefficients produced by this methodology.

Another possible test of these coefficients is as integral parts of the Yellowstone cumulative effects model (Weaver and others this volume) used for generating habitat effectiveness and mortality risk in specific large-scale management areas. Density of radio-telemetry fixes accumulated over our 10-year study period could be used as a quasilegitimate independent test of management area habitat effectiveness values and, more indirectly, of the habitat component coefficients integral to calculation of the effectiveness values.

REFERENCES

Aune, Keith; Stivers, Tom. Rocky Mountain Front grizzly bear monitoring and investigation. Helena, MT: Montana Department Fish, Wildlife and Parks; 1981. 50 p.

Blanchard, Bonnie M. Field techniques used in the study of grizzly bears. Bozeman, MT: U.S. Department of the Interior, National Park Service, Interagency Grizzly Bear Study Team. 24 p.

Christensen, A. G. Cumulative effects analysis process. Libby, MT: U.S. Department of Agriculture, Forest Service, Kootenai National Forest; 1982. 21p. Unpublished report.

Craighead, John J.; Sumner, J. S.; Scaggs, G. B. A definitive system for analysis of grizzly bear habitat and other wilderness resources. Wildlife-Wildlands Institute Monograph No. 1. Missoula, MT: University of Montana Foundation; 1982. 279 p.

Gregory, Shari K. Subalpine forb community types of the Bridger-Teton National Forest, Wyoming. Contract Completion Report to U.S. Forest Service; 1983. 62 p.

Hall, Charles A. S.; Day, John W., Jr. Systems and models: terms and basic principles. In: Hall, Charles A. S.; Day, John W., Jr., eds. Ecosystem modeling theory and practice. New York: John Wiley & Sons; 1977: 5-36.

Knight, Richard R.; Mattson, David J.; Blanchard, Bonnie M. Movements and habitat use of the Yellowstone grizzly bears. Report for the Interagency Grizzly Bear Committee. Bozeman, MT: U.S. Department of the Interior, National Park Service; 1984. 177 p.

Mace, Richard David. Identification and evaluation of grizzly bear habitat in the Bob Marshall Wilderness Area, Montana. Missoula, MT: University of Montana; 1984. 176 p. M.S. thesis.

Marcum, C. Les; Loftsgaarden, Don O. A nonmapping technique for studying habitat preferences. Journal of Wildlife Management. 44(4): 963-968; 1980.

Mattson, David John. Classification and environmental relationships of wetland vegetation in central Yellowstone National Park. Moscow, ID: University of Idaho; 1984. 409 p. M.S. thesis.

Mattson, David J.; Knight, Richard R.; Blanchard, Bonnie M. Foraging strategies and feeding activities of the Yellowstone grizzly bear. Bozeman, MT: U.S. Department of the Interior, National Park Service, Interagency Grizzly Bear Study Team; [in preparation].

Mattson, David J.; Despain, Don G. Grizzly bear habitat component mapping handbook for the Yellowstone ecosystem. U.S. Department of the Interior, National Park Service, and U.S. Department of Agriculture, Forest Service; 1985. 37 p.

Mealey, Stephen P.; Jonkel, Charles J.; Demarchi, Ray. Habitat criteria for grizzly bear management. Proceedings--XIIIth Congress of Game Biologists; 1977 March 11-15:276-289.

Mueggler, W. F.; Stewart, W. L. Grassland and shrubland habitat types of western Montana. General Technical Report INT-66. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 154 p.

Neu, Clyde W.; Byers, C. Randall; Peek, James M. A technique for analysis of unitization-availability data. Journal of Wildlife Management. 38(3): 541-545; 1974.

Pfister, Robert D.; Kovalchik, Bernard L.; Arno, Stephen F.; Presby, Richard C. Forest habitat types of Montana. General Technical Report INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Salwasser, Hal; Mealey, Stephen P.; Johnson, Kathy. Wildlife population viability--a question of risk. In: Proceedings, 49th North American Wildlife and Natural Resources Conference; 1984 March 27; Boston, MA. [in press].

Servheen, Christopher. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. Journal of Wildlife Management. 47(4): 1026-1035; 1983.

Shannon, C. E.; Weaver, W. The mathematical theory of communication. Urbana, IL; University of Illinois Press; 1963. 117 p.

Steele, Robert; Cooper, Stephen V.; Ondov, David M.; Roberts, David W.; Pfister, Robert D. Forest habitat types of eastern Idaho-western Wyoming. General Technical Report INT-144. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 122 p.

Zager, Peter; Jonkel, Charles; Habeck, James. Logging and wildfire influence on grizzly bear habitat in northwestern Montana. International Conference on Bear Research and Management. 5: 124-132; 1980.

APPENDIX

Variables: calculation of unit area habitat value.

N_{ijk} = number of community site analyses of feeding activity type i in habitat type j during season k.

NT_{jk} = total number of community site analyses in habitat type j during season k.

NT'_{jk} = total number of community site analyses with recorded feeding activity in habitat type j during season k.

NF_{ik} = total number of community site analyses of feeding activity type i during season k.

N_k = total number of community site analyses during season k.

P_j = proportionate area of habitat type j.

HTN_k = number of habitat components utilized by grizzly bear during season k.

UFV_{ik} = unit area food value of diem item i associated with feeding activity type i.

$$X_{ijk} = N_{ijk}/NT_{jk}$$

$$X_{ijk} = N_{ijk}/NT'_{jk}$$

$$Y_{ijk} = N_{ijk}/NF_{ik}$$

$$Y_{jk} = NT_{jk}/N_k$$

$$H'_{jk} = \sum_{i=1} X'_{ijk} \ln X'_{ijk}$$

$$DI_{jk} = ((0.667/H'_{jk\ max})H'_{jk}) + 0.333$$

$$PF_{ijk} = -\ln(Y_{ijk}/Y_{jk});^{a}$$

$$(-\ln (Y_{ijk}/Y_{jk}) + (Y_{ijk}/Y_{jk}))/2;^{b}$$

$$Y_{ijk}/Y_{jk}\ ^{c}$$

$$APF_{ijk} = PF_{ijk}/PF_{jk\ max}$$

$$F_k = HTN_{max}/HTN_k$$

$$PS_{ijk} = \sum_{j=1} UFV_{ik} * X_{ijk} * APF_{ijk}$$

$$UHV'_{jk} = ((\sum_{j=1} UFV_{ik} * X_{ijk} * APF_{ijk}) * DI_{jk} * F_k)/UHV_{jk\ max}$$

Variables: allocation of estimated number of feed sites among habitat components.

FQS_{ik} = scat frequency of diet item i during season k.

NM_{ik} = number of months during which scat frequency of diet item i was recorded during season k.

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[a]If $Y_{jk} \leq 0.25$.

[b]If $Y_{jk} > 0.25$ and ≤ 0.75.

[c]If $Y_{jk} > 0.75$.

P_j can substitute for Y_{jk} in all calculations of PF_{ijk}.

R_{jmk} = relative rank of month m, by number of community site analyses (total) in type j during season k.

RS_{imk} = relative rank of month m, by relative scat volume of diet item i during season k.

N_{jk} = total number of community site analyses in type j during season k.

FQ_{ij} = relative frequency of diet item i in plots of habitat component type j.

$\widehat{NFFQ}$ = estimated number of feed sites recorded by radio relocation community site analysis per unit of relative frequency for any diet item i in scats.

$$\widehat{NF}_{ik} = \widehat{NFFQ} * FQS_{ik}$$

$$FID_{ijk} = (\sum_{m=1} \left[RS_{imk} - R_{jmk} \right])/NM_{ik}$$

$$AFID_{ijk} = 1 - (FID_{ijk}/NM_{ik} - 1)$$

$$FQ'_{ij} = FQ_{ij}/FQ_{ij\ max}$$

$$NT'_{jk} = NT_{jk}/NT_{jk\ max}$$

$$AS_{ijk} = FQ'_{ij} * NT'_{jk} * AFID_{ijk}$$

$$\hat{N}_{ijk} = \widehat{NF}_{ik} (AS_{ijk}/ \sum_{j=1} AS_{ijk})$$

HABITAT TYPE AND COVER TYPE AS A BASE FOR GRIZZLY BEAR HABITAT MAPPING AND EVALUATION

Don G. Despain

ABSTRACT: Habitat type is a widely used classification system that indicates site potential. The system is based on the assumption that site characteristics are integrated by the plants growing on the site. Thus, plants can be used to rapidly assess site potential. One parameter that is not addressed by the system is successional stage, or time since last disturbance. Cover type in forested communities is a simple classification of age classes that can be combined with habitat type to provide this information. If both habitat type and cover type are known for a site, it is possible to predict a large suite of site parameters that are critical for grizzly bear habitat evaluation, such as the probability of finding bear foods, year-to-year variability in site conditions, and site productivity. This information, in a computerized geographic information system, provides excellent spatial evaluation possibilities.

The method of habitat evaluation presented here has a large number of classes and provides much finer resolution than those used in other Rocky Mountain ecosystems, where only a few very broad classes are mapped and used in the evaluation process.

INTRODUCTION

Plant communities are a significant variable in the grizzly bear survival equation because grizzly bears obtain their food and cover from plants both directly and indirectly. Some plant communities provide abundant grizzly bear food and cover; others produce little. The ability to stratify this heterogeneity is therefore essential to an assessment of the effects of human activities on the grizzly bear environment.

Most studies relating grizzly bears to habitat in the Northern Rocky Mountain region have used a system developed in northwestern Montana (Zager and others 1983; Servheen 1981). That system stratifies the vegetation into 20 or fewer broad classes and emphasizes nonforested vegetation and various disturbance communities. Forested communities are treated simply as timber or as two or three classes of timber with various tree densities; however, in the Yellowstone ecosystem, some forested communities are quite important to the grizzly bear, especially whitebark pine (Pinus albicaulis) stands.

The habitat type system provides a good method of stratifying the physical environment and therefore the productivity of forested and nonforested sites (Daubenmire 1968). Unsworth (1984) and Young (1984), however, related habitat type to black bear activity and concluded that habitat type was not useful because there was no classification of nonforested types in their area, and most timbered sites were in a seral stage not addressed by the habitat type system. If, however, both habitat type and successional stage of the stands in an area are known, it should be possible to infer related information about the sites. This would allow rapid assessment of large areas and still give good resolution.

HABITAT TYPES

Many factors determine the growing conditions of a site and thus the plant species present. Some of these are easily measured, and some are not. Because we may not be aware of some important factors, direct measurement of all factors influencing a site is impractical, if not impossible.

All factors influencing a site are integrated by plants on that site; therefore, the plant community on a site is a good indirect indication of site conditions. This integration by the plants is the basis of the habitat type classification system developed more than 30 years ago by Daubenmire (1952). Since that time, it has been refined and applied to a large portion of the Rocky Mountain forests (Pfister and others 1977) and some nonforest vegetation (Mueggler and Stewart 1978; Hironaka and others 1983; Mattson 1984).

Inferences about site potential or ability to produce certain plant communities, as well as biomass production potential, can be made if the habitat type is known. Habitat types have been used to describe potential tree reproduction on logging sites (Pfister 1972), the amount of lumber to expect from a logging sale (Stage 1973), and the distribution of bird species (Weaver 1985).

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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With habitat types, the landscape can be classified into discrete units of similar potential. These units can be mapped and the geographical relationships determined. Within the limits of precision of the classification and the mapping efforts, the potential of a very large area can be ascertained.

Although the habitat type system is based on climax or near climax communities, we can properly classify younger stands by observing the species in the understory and forest floor and by comparing them with older communities on similar sites. Further studies can be made to describe the various plant communities of each successional stage (see Arno 1982).

COVER TYPES

Some important characteristics of the existing plant community are determined by the time elapsed since last disturbance (succession). In forested communities this is usually expressed by the size and species of trees on a site.

Succession is a continuous process, but it can be divided into classes such as early, mid, and late stages. Adding recently disturbed and climax classes provides five easily recognizable and ecologically meaningful classes (Despain 1977). In the greater Yellowstone area, forested stands are dominated by relatively few species. Lodgepole pine (*Pinus contorta*), Douglas-fir (*Pseudotsuga menziesii*), whitebark pine, or a combination of Engelman spruce (*Picea engelmannii*), and subalpine fir (*Abies lasiocarpa*) are the most common stand dominants, but limber pine (*Pinus flexilis*) and aspen (*Populus tremuloides*) are also present and locally important. Each of these can provide both climax and successional stands depending on site conditions.

Dividing these dominants into successional stages produces 25 major cover types. These types are shown in the following list and described in more detail along with a few minor types in Mattson and Despain (1985). These classes are called cover types, indicating a classification based only on tree cover. All stands can be placed into both cover type and habitat type classifications.

Type Cover	Description
LPO	Recently burned or harvested stands dominated by lodgepole pine.
LP1	Even-aged, usually dense stand of lodgepole pine.
LP2	Mature stand of lodgepole pine.
LP3	Overmature stand of lodgepole pine.
LP	Climax stand of lodgepole pine.
DFO	Recently burned or harvested stands dominated by Douglas-fir.
DF1	Even-aged, usually dense stand of Douglas-fir.
DF2	Mature stand of Douglas-fir.
DF3	Overmature stand of Douglas-fir with spruce and fir in the understory.
DF	Climax stand of Douglas-fir.
SFO	Recently burned or harvested stands dominated by spruce and fir.
SF1	Even-aged, usually dense stand of spruce and fir, usually in cool, wet environments.
SF	Climax stand of spruce and fir.
WBO	Recently burned or harvested stands dominated by whitebark pine.
WB1	Even-aged, usually dense stand of whitebark pine.
WB2	Mature stand of whitebark pine.
WB3	Overmature stand of whitebark pine.
WB	Climax stand of whitebark pine.
ASPO	Recently burned or harvested stands dominated by aspen.
ASP1	Even-aged, usually dense stand of aspen.
ASP2	Mature stand of aspen.
ASP3	Overmature stand of aspen with conifer understory.
ASP	Climax stand of aspen.
L13	Overmature stand of limber pine with codominants and understory of other conifers.
L1	Climax stand of limber pine.

Grassland and shrubland habitat types occur across the landscape but at a different scale of resolution than forest types. A map of grassland habitat types would have a much higher polygon density than a forest map simply because microsite differences are more influential on the smaller statured individuals of the grassland. The need for rapid assessability and the constraints of computer memory size made it necessary to group nonforested habitat types into larger, more encompassing units. These were separated into grasslands, herblands, and shrublands, then subdivided into dry, moist, and wet types (see Mattson and Despain 1985 for full descriptions).

Disturbance and succession also occur in nonforested areas but, aside from grazing, most of the disturbances are limited. Pocket gophers are probably the most significant disturbance in grasslands and shrublands of the Yellowstone ecosystem. Gophers cause site disturbance themselves, and further disturbance results when grizzly bears dig for this important food source. These small disturbed areas are not easily distinguished on air photos.

Grazing occurs over large areas, but it is closely monitored and regulated and the pressure remains fairly constant; thus plant communities remain fairly stable. Considering all these factors, it was not deemed necessary to map differences in successional stages of the nonforested area.

The capacity of the different habitat classes to provide grizzly bear food and cover must be determined before this system can be used to assess the value of the area to these large omnivores. This has been done for the Yellowstone ecosystem and is reported by Mattson elsewhere in this volume. A value to the grizzly bear has been derived for each of the habitat type/cover type combinations. This value, when multiplied by the acres of each type, summed across all the types in an area, and modified by other values stemming from landscape relationships, gives the potential vegetational value of that area to the bear (Weaver and others this proceedings).

COMPONENT MAPPING

Previous studies in the Yellowstone ecosystem have provided a good information base for this area. Habitat types have been described for both forested and nonforested vegetation (Pfister and others 1977; Steele and others 1983; Cooper 1975; Mueggler and Stewart 1978; Hironaka and others 1983; Mattson 1984).

Mapping is quickly accomplished in several steps (Mattson and Despain 1985). Air photos are scanned stereoscopically and both nonforest and forest stands are delineated and given a temporary designation. The major tree species in the Yellowstone ecosystem are readily discernible on air photos, and different age classes are fairly easy to distinguish. This makes stand delineation fairly easy, but habitat type identification from air photos is more difficult. Representative variations in the delineated stands are selected from air photos and then examined on the ground to determine habitat and cover type. These observations are then extrapolated to neighboring stands and air photos. Very large areas can thus be efficiently mapped, and the result is a detailed map of habitat value.

These maps are then digitized and can be used in computerized geographic information systems to analyze, plan, and assess alternatives.

Both habitat type and cover type have been mapped in Yellowstone National Park. Mapping of adjacent Forest Service land by habitat type and cover type is estimated to be 50 to 70 percent complete.

SUMMARY

Grizzly bears are biological organisms that depend on biological products for survival. This statement of the obvious must be kept clearly in mind when assessing the ability of a given piece of landscape to support grizzly bears or evaluating the effects of human activity on the grizzly bear population. Variation is an almost universal characteristic of biological systems. The variation inherent in individual organisms is compounded by the variation encompassed by a population. This means that there are few absolutes in the relationships of bears to their environments. Habitat types in conjunction with cover types provide a small-scale model of this variation on which to base habitat assessment for a very large area.

There are several advantages to using habitat type/cover type as the base map. Many areas have already been mapped by habitat type for timber purposes, reducing the need for field work. Because cover types can be reliably assessed from air photos, we can obtain more detailed maps with higher resolution and, more importantly, we can use this base map for other species by simply determining the value of the vegetation types to that species and reanalyzing the habitat using those values.

ACKNOWLEDGMENTS

I am indebted to Dave Mattson for helping me see the need for this paper, to Pete Zager for making it more informative and readable through his reviews and helpful comments, and to Margaret Holland and Emily Anderson for typing and proofreading.

REFERENCES

Arno, S. F. Classifying forest succession on four habitat types in western Montana. In: Means, J.E., ed. Forest succession and stand development research in the northwest: symposium proceedings; 1981 March 26; Corvallis, OR: Oregon State University; 1982: 54-62.

Cooper, S. V. Forest habitat types of northwestern Wyoming and contiguous portions of Montana and Idaho. Pullman, WA: Washington State University; 1975. 190 p. Dissertation.

Daubenmire, R. Vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecol. Monogr.22: 301-330; 1952.

Daubenmire, R. Plant communities: a textbook of plant synecology. New York: Harper and Row; 1968. 300 p.

Despain, D. G. Forest successional stages in Yellowstone National Park. Inf. Pap. 32. Yellowstone National Park, WY: U.S. Department of the Interior, National Park Service; 1977. 3 p. Unpublished mimeograph.

Hironaka, M.; Fosberg, M. A.; Winward, A. H. Sagebrush-grass habitat types of southern Idaho. Bull. No. 35. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station; 1983. 44 p.

Mattson, D. J. Classification and environmental relationships of wetland vegetation in central Yellowstone National Park. Moscow, ID: University of Idaho; 1984. 409 p. M.S. thesis.

Mattson, D. J.; Despain, D. G. Grizzly bear habitat component mapping handbook for the Yellowstone ecosystem. 1985. Unpublished review draft on file at: U.S. Department of the Interior, National Park Service, Yellowstone National Park, WY.

Mueggler, W. F.; Stewart, W. L. Grassland and shrubland habitat types of western Montana. Gen. Tech. Rep. INT-66. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1978. 154 p.

Pfister, R. D. Habitat types and regeneration. In: Permanent Association Committees Proceedings. Portland, OR: Western Forestry and Conservation Association; 1972: 120-125.

Pfister, R. D.; Kovalchik, B. L.; Arno, S. F.; Presby, R. C. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Servheen, C. Grizzly bear ecology and management in the Mission Mountains, Montana. Missoula, MT: University of Montana; 1981. 136 p. Ph. D. dissertation.

Stage, A. R. Prognosis model for stand development. Res. Pap. INT-137. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 32 p.

Steele, R.; Cooper, S. V.; Ondov, D. M.; Roberts, D. W.; Pfister, R. D. Forest habitat types of eastern Idaho-western Wyoming. Gen. Tech. Rep. INT-144. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 122 p.

Unsworth, J. W. Black bear habitat use in west-central Idaho. Bozeman, MT: Montana State University; 1984. 96 p. M.S. thesis.

Weaver, T. [Personal communication.] Bozeman, MT: Montana State University, Department of Biology, 1985.

Young, D. D. Black bear habitat use at Priest Lake, Idaho. Missoula, MT: University of Montana; 1984. 66 p. M.S. thesis.

Zager, P. E.; Jonkel, C.; Habeck, J. Logging and wildfire influence on grizzly bear habitat in northwestern Montana. Int. Conf. Bear Res. and Manage. 5: 124-132, 1983.

A CUMULATIVE EFFECTS MODEL FOR GRIZZLY BEAR MANAGEMENT IN THE YELLOWSTONE ECOSYSTEM

John Weaver, Ron Escano, David Mattson, Tom Puchlerz and Don Despain

ABSTRACT: Cumulative effects may be defined as the combined effect upon a species and its habitat resulting from multiple land uses over space and time. A Cumulative Effects Model (CEM) has been designed to (1) quantify individual and collective effects of land uses and activities in space and through time and (2) provide managers an analytic tool for evaluating alternative decisions relative to grizzly bear recovery goals and objectives. The CEM is composed of three submodels: habitat, displacement, and mortality. The habitat and displacement submodels determine the habitat effectiveness value of an area while the mortality submodel portrays mortality risks. The submodels integrate basic variables that are significant and subject to management. The habitat submodel incorporates four variables: (1) food and thermal cover, (2) habitat diversity, (3) seasonal equity, and (4) denning suitability. These variables combined indicate the year-round habitat quality of an area. The displacement submodel includes four variables of human activity: (1) location relative to hiding cover, (2) type (motorized or nonmotorized), (3) nature (linear, point, or dispersed), and (4) intensity (high or low use, day or overnight use). Displacement is characterized by a coefficient of disturbance and by an associated zone of influence. The mortality submodel incorporates four variables of human activity: (1) location relative to habitat quality, (2) nature, (3) intensity and sanitation, and (4) firearms. By integrating the submodels, the CEM provides two basic outputs: habitat effectiveness value and mortality risk index. Once thresholds appropriate for grizzly bear recovery are established for habitat effectiveness and mortality risk, managers can manipulate the numerous variables and analyze the competitive and cumulative effects of various land uses through computer simulations.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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INTRODUCTION

The Endangered Species Act necessitates that the cumulative effects of land uses and management activities upon a listed species be evaluated as part of the biological assessment process. Cumulative effects can be defined as the combined effect upon a species or its habitat caused by the activity or program at hand, as well as other reasonably foreseeable events that are likely to have similar effects upon that species or its habitat. Cumulative effects can result from individually minor but collectively significant events taking place over time.

In January 1984, the Yellowstone Ecosystem Management Subcommittee of the Interagency Grizzly Bear Committee identified the need to develop a cumulative effects assessment process for the ecosystem. The charge developed by the Subcommittee was: Develop methodology to quantitatively and qualitatively assess the cumulative effects of human activity on grizzly bear habitat, habitat use, and mortality in the Yellowstone Ecosystem. A task team of representatives from USDA Forest Service, Yellowstone National Park, and the Interagency Grizzly Bear Study Team was assigned the charge.

Because a myriad of demands has been placed on public and private lands within the Yellowstone Ecosystem, cumulative effects analysis has become an integral part of biological evaluations being prepared in occupied grizzly bear habitat. Moreover, the cumulative effects process can and should be used as an effective tool in proactive management of grizzly bear habitat.

APPROACH

Early in the cumulative effects process it became apparent that computer implementation would be necessary. The process therefore was modeled for computer implementation and is now referred to as the Cumulative Effects Model (CEM).

Design

The CEM is designed to (1) quantify individual and collective effects of land uses and activities in space and through time and (2) provide managers with an analytic tool for evaluating alternative decisions relative to grizzly bear recovery goals and objectives.

The CEM is composed of three submodels: habitat, displacement, and mortality (fig. 1). The habitat and displacement submodels determine the habitat effectiveness value of an area while the mortality submodel determines the mortality risks. The submodels integrate basic variables that can be significant and subject to management.

The habitat submodel incorporates four variables: (1) food and thermal cover, (2) habitat diversity, (3) seasonal equity, and (4) denning suitability. These basic variables combined indicate the year-long habitat quality of an area (see Habitat Submodel section for details).

The displacement submodel includes four variables of human activity: (1) type of activity (motorized, nonmotorized, or explosive); (2) nature of activity (linear, point, or dispersed); (3) length of activity (diurnal or 24-hour); and (4) disturbance intensity (high or low). Displacement is characterized by a coefficient of disturbance and by an associated zone of influence (see Displacement Submodel section for details). The displacement submodel is directly linked to the habitat submodel through the food/cover variable.

The mortality submodel incorporates five basic variables regarding human activity: (1) habitat quality, (2) nature of activity (point, linear, or dispersed), (3) intensity of use, (4) availability of attractants, and (5) presence of firearms. The relative risk of mortality can be compared among activities (see Mortality Submodel section for details). The mortality submodel is indirectly linked to the habitat submodel through habitat quality and to the displacement submodel through the nature and intensity of human activity.

By integrating the submodels, the CEM provides two basic outputs: habitat effectiveness value and mortality risk index.

Development

Development of the CEM requires two basic steps: deriving and mapping the habitat components, and categorizing and mapping the land uses and activities.

A series of digitized base maps displaying habitat/cover types for forested habitat components, nonforested habitat components, ungulate seasonal ranges and trout spawning

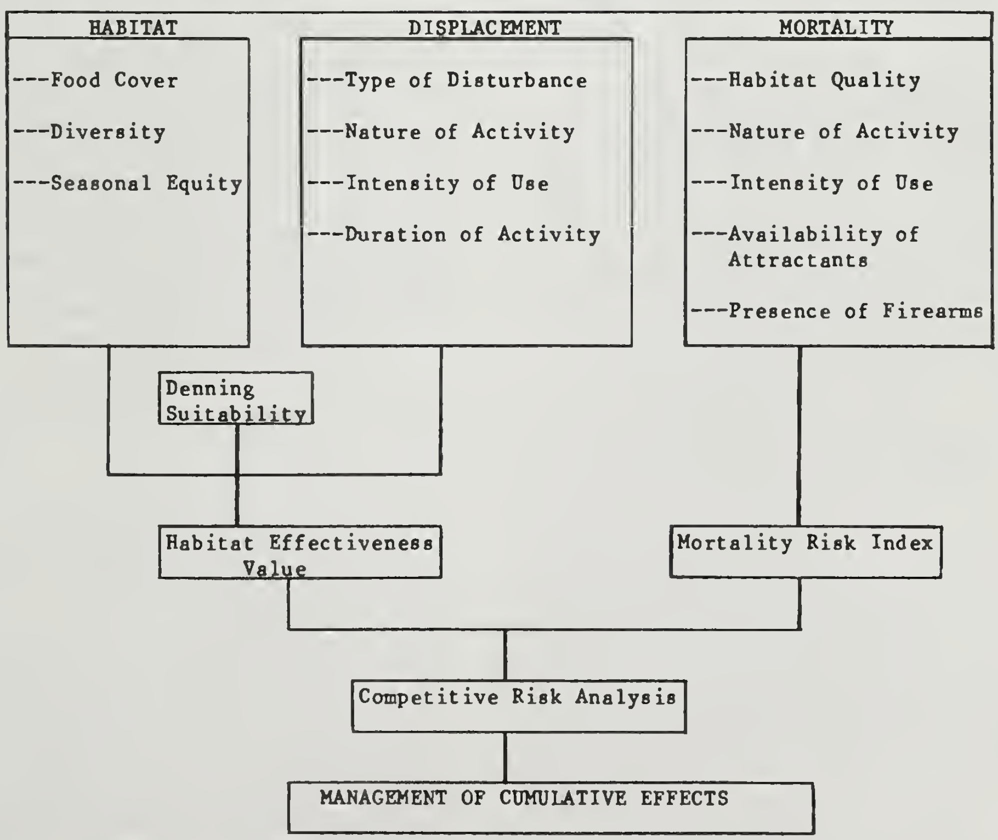

Figure 1.--A cumulative effects model for grizzly bear management in the Yellowstone ecosystem.

streams to a 5-acre resolution are generated. Both existing and potential habitat values for unique cells (polygons on the final composite map) are generated by season and stored in a computer file.

A series of digitized overlay maps showing location and nature/type of existing land uses and a file of associated coefficients for displacement and mortality are generated. The independent and combined effects upon habitat effectiveness value and mortality risk index are generated by month and stored in a computer file.

Once thresholds appropriate for grizzly bear recovery are established for the two outputs, managers can manipulate the numerous variables and analyze the competitive and cumulative risks of various land uses through computer simulations.

Delineation of Grizzly Bear Management Units

To deal with an ecosystem as large as Yellowstone, it was necessary to divide the area into smaller units to: (1) assess existing and proposed activities without having the effects diluted by consideration of too large an area, (2) closely match individual grizzly bear use patterns and habitat ecology, and (3) prioritize areas where management would require a cumulative effects analysis.

Bear management units (BMU's) were delineated using grizzly bear radio location data and topographic features. The entire area within currently designated occupied grizzly bear habitat was stratified into bear management units.

Initially, areas were delineated that had a substantial number of radio locations during 0, 1, 2, or 3 "active" seasons. Active seasons were considered to be spring (March through May), summer (June through August), and fall (September through November). Areas of extensive and contiguous substantial three-season use as well as areas without substantial use during any season were identified.

All areas with extensive and contiguous three-season use serve as a core for a bear management unit. Prominent topographic features between adjacent core areas with three-season use serve as unit boundaries. Where an area with "nonuse" or one- to two-season use adjoins one with three-season use, a prominent topographic feature closest in proximity to the area with three-season use serves as a boundary.

As a consequence, some BMU's contain extensive areas of known substantial three-season bear use (Madison, Washburn, Lamar/Slough, Crandall/Sunlight, Firehole/Hayden, Pelican/Clear, and Two Ocean/Lake). Other units are characterized by virtually no bear use (Boulder, Teton, Plateau, and Henry's Lake). These minimal-use units all occur around the periphery of occupied grizzly habitat. Other units (Gallatin, Hellroaring/Bear, Shoshone, Thorofare, Bechler/Grassy Lake) have substantial bear use during only one to two seasons or have only a limited area of three-season use.

Subunit Delineation

Subunits provide further landscape resolution as well as finer attunement to grizzly bear habitat use patterns. Subunits are delineated on the basis of seasonal component representation and interspersion. An optimal subunit corresponds to a contiguous but more or less interspersed area of spring range accompanied, in fairly close proximity, by significant areas of summer and fall range. This complex is typically encompassed by a major drainage and portions of intervening ridges. On the other hand, some subunits are distinguished (as are some units) by a uniform lack of high-value seasonal components or by the presence of high-value feeding opportunity during only one or two seasons. In the latter case, the one or two seasonal components are too far distant from other seasonal components for a substantial number of bears to efficiently integrate them in yearly ranges.

A subunit corresponds to the optimal scale for incorporating information on grizzly bear habitat utilization. Insufficient information is contained at the individual polygon, or component, level pertaining to important factors such as equity of seasonal feeding opportunities and landscape patterns of food availability. At the unit level, too much extraneous information may obscure recognition of the most energetically efficient area that a grizzly bear can use. Subunits will be delineated once habitat mapping of the unit is complete.

HABITAT SUBMODEL

Description

The habitat submodel provides a relative numeric evaluation of grizzly bear habitat expressed as "habitat value." Habitat value can reflect both potential and existing conditions and incorporates food, cover, habitat diversity, and equity of seasonal feeding opportunity. Value attributable to denning habitat is not incorporated directly in the submodel because denning habitat is not considered to be limiting in the Yellowstone ecosystem (Judd and others, in press).

The habitat submodel provides a habitat value (UHV_i) for each bear management unit. This

value (UHV_i) is an average of subunit habitat values ($SUHV_{pi}$) weighted by relative area. Subunits are therefore the primary management level at which grizzly bear habitat values are calculated. Subunit habitat values are relative and thus meaningful only in comparison to other units or subunits.

Habitat value of a subunit (10000 to 40000 ha) depends not only on average food and cover values but also on diversity attributable to edge density and on the consistency or equity of feeding opportunity across seasons during which bears are actively foraging. Landscape diversity or edge density and seasonal feeding opportunity equity are treated as attributes of a management subunit in this model and only indirectly as attributes of a management unit. Subunit values ($SUHV_{pi}$) are therefore a direct function of mean habitat value (MHV_{pi}), which incorporates the effect of edge density and of seasonal subunit value equity (E_{pi}).

Increased continuity of feeding opportunity across seasons is considered to increase the habitat value of a subunit. Evenness or continuity of feeding opportunity would logically result in greater fidelity of bears to an area (subunit). This greater fidelity is a probable consequence of increased efficiency of habitat exploitation. Thus, as disparity of subunit seasonal values (SHV_{pik}) increases, mean subunit habitat value (MHV_{pi}) decreases.

An index, E_{pi}, of seasonal feeding opportunity equity is utilized in submodel calculations. E_{pi} is an adjusted coefficient of variation for seasonal subunit habitat value (SHV_{pik}). Decreased E_{pi} corresponds to increased disparity in seasonal values. MHV_{pi} is therefore reduced as a direct function of E_{pi}'s fractional value which is constrained to a minimum value of 0.667.

Mean subunit habitat value (MHV_{pi}) is the average seasonal subunit values (SHV_{pik}) calculated for spring, summer, and fall. SHV_{pik} is an area-weighted mean of individual component habitat values (HV_{jku}). Subunit habitat value (SHV_{pik}) primarily reflects foraging opportunity, although value attributable to thermal and security cover is also integrated. Greater seasonal habitat value primarily reflects greater quality and diversity of available foods over a broader area.

Individual component habitat values (HV_{jku}) are derived from base unit area component habitat values (UHV'_{jku}). Base unit area component value integrates value of characterisitic available foods, diversity of feeding opportunity, and feedsite density or preference for each habitat component by season (spring, summer, or fall) (Mattson and others this volume). Two factors are applied to base unit area values (UHV'_{jku}) to derive individual component values (HV_{jku}): (1) adjustment (Cvr_{tk}) based on a specific distance threshold from forest-nonforest edge into both forest and nonforest stands (table 1) and (2) adjustment (Ung_{tk} or Trt_{tk}) based on inclusion in protein-rich areas (table 2).

Grizzly bears are known to prefer forest-nonforest ecotones in the Yellowstone ecosystem (Graham 1978; Blanchard 1983; Brannon 1984; Schleyer and others 1984). Base unit area component values are adjusted according to distance from an ecotone, with coefficients defined by frequency distribution of recorded feedsites. Yellowstone grizzly bears also prefer ungulates and cutthroat trout (Cole 1972; Schleyer 1983; Knight and others 1984). An additional factor is applied to base unit area values that accounts for value added by extensive concentrations of protein-rich foods. This adjustment varies according to the type of protein-rich food and, for ungulates, the season and type of range.

Base unit area habitat values (UHV'_{jku}) range from a maximum of 1.291 to a minimum of 0. Base unit area values also vary for each component according to presence of ungulate concentrations and season. A benchmark base value of 1.000 is accorded the habitat type (unadjusted for cover type) with greatest seasonal value. Tabular values for the base unit area components are available from D. Mattson.

In this submodel, habitat components correspond to combinations of habitat type and cover type. Comparison of tabular values is meaningful only when stratified by presence (UNG) or absence (W/O UNG) of protein-rich food concentrations. Comparison between the two strata or categories is legitimate only after multiplying the UNG value by an appropriate factor (Ung_{tk} or Trt_{tk}) adjusting for the type of protein-rich food present and the type of ungulate range.

In summary, calculated subunit habitat value varies according to area representation and base unit area value of habitat components, presence of ungulate concentrations and cutthroat trout spawning streams, interspersion of forest and nonforest components, equity of feeding opportunity through the bears' active seasons, and habitat type diversity. Highest values correspond with subunits having concentrations of ungulates, trout spawning streams, high habitat diversity, equity of seasonal feeding opportunity, habitat components with uniformly high base unit area values, high density of forest-nonforest edge, and forest cover at optimal successional stages.

Variables

A_{pij} = total area representation of habitat component j in subunit i of unit p.

SUA_{pi} = total area of subunit i in unit p.

UA_{p} = total area of unit p.

P_{pih} = proportionate area representation of habitat type (or habitat type aggregate) h in subunit i of unit p.

UHV'_{jku} = base unit area value of component j during season k in protein-rich strata u.

Trt_{tk} = adjustment factor for inclusion in influence zone of cutthroat spawning stream type t during season k.

Ung_{tk} = adjustment factor for presence of ungulate concentrations on range type t during season k.

Cvr_{tk} = adjustment factor for distance zone x from forest-nonforest edge into cover type t during season k.

HV_{jku} = $UHV'_{jku} * Cvr_{xtk} * (Trt_{tk}$ or $Ung_{tk})$

SHV_{pik} = $(\ _{j=1} A_{pij} * HV_{jku})/SUA_{pi}$

MHV_{pi} = $(\ SHV_{pik})/3 \ k=1$

E_{pi} = $1-(SHV_{pik}-MHV_{pi})^2/MHV_{pi})/4.242)$

$SUHV_{pi}$ = $MHV_{pi} * E_{pi}$

UHV_{p} = $(\ _{i=1} SUA_{pi} * SUHV_{pi})/UA_{p}$

Assumptions

1. Area habitat quality is substantially a function of cover and food availability.

2. Where human presence is not a factor, food availability considerably outweighs cover and denning habitat in contribution to area habitat value or quality.

3. Feeding-site, scat, and radio location data collected by the IGBST are representative of the grizzly bear population in the greater Yellowstone area.

4. Habitat type, with cover type superimposed, is an accurate predicator of food and cover value for grizzly bear within an area of 10000 to 40000 ha.

5. Subunit habitat value is accurately predicted by habitat diversity, equity of feeding opportunity through the bears' active seasons, habitat type (or component) representation, and presence of animal food sources.

Operation

Successive incorporation of habitat values culminating in grizzly bear management unit habitat values is as follows:

UHV'_{jku} - base unit area component habitat value

HV_{jku} - unit area component habitat value

SHV_{pik} - seasonal subunit habitat value

MHV_{pi} - mean subunit habitat value

$SUHV_{pi}$ - subunit habitat value

UHV_{p} - management unit habitat value

DISPLACEMENT SUBMODEL

Description

The displacement submodel quantifies the effects of disturbance associated with human activities on the grizzly bear's ability to use an area. The interaction of habitat quality and displacement determines the habitat effectiveness (actual carrying capacity). The following steps were used to develop this submodel: (1) stratify all activities and human uses occurring in the Yellowstone Ecosystem into groups reflecting similar effects; (2) assign disturbance coefficients and zones of influence for each activity group; (3) identify how the effects of disturbance for a specific area or project are aggregated in space and time; and (4) identify the procedures to operate the submodel.

Variables

Activities and human uses that occur in the Yellowstone ecosystem were stratified into groups having similar disturbance potentials. Activity lists typically reflect the type of user or function responsible for the activity (e.g., timber harvest, campground, or oil and gas drilling). Such an activity list would be lengthy. Grouping activities by the degree

and type of disturbance not only reduces the number of categories but also simplifies the analysis without giving up model resolution.

Thirteen activity groups, stratified by the following criteria, were identified:

1. Type of activity (motorized, nonmotorized, or explosive)

2. Nature of the activity (linear, point, or dispersed)

3. Length of activity (diurnal or 24-hour)

4. Disturbance intensity (high or low)

The type of activity is determined by the dominant disturbance element associated with the activity. If the activity is primarily mechanized and produces loud equipment noises, it is motorized. Otherwise, it is nonmotorized. With above-ground explosives, the activity type is explosive. The activity groups, including definitions and specific examples of activities, are shown in table 1.

Disturbance Coefficients/Zones of Influence

Disturbance coefficients and zones of influence for each activity group were identified using the team's subjective ratings. Available research data were collected primarily in other grizzly bear ecosystems and not considered representative of grizzly behavior in the Yellowstone ecosystem. The zone of influence identifies the distance in which grizzlies would be affected by the activity, and the coefficient identifies the degree of disturbance (on a scale of 0.0 to 1.0) within the zone of influence. When selecting the zone of influence, ridgeline and line-of-sight distances are used when they are less than the mileage estimate. Disturbance can influence bear use in two ways: actual displacement and change in use patterns that reduce the time available for a bear to use an area (for example, 24-hour to nocturnal use periods). Both of these factors were considered in coefficient development. Cover was considered important in determining both the zone of influence and the degree of disturbance. Cover is defined as that vegetation capable of hiding 90 percent of a standing adult bear from view of a human at a distance equal to or less than 60 m. Separate values were developed for cover and noncover situations. Another consideration in coefficient development was habituation to recurring (predictable), nonthreatening activities. Attractions associated with various activities that might override the bear's flight response were not considered in this submodel. Attractions associated with a given activity are a key element in the mortality submodel.

We did not assume that all bears would be displaced from an activity's zone of influence. Instead we estimated what percent of the bears would still use the zone of influence for what percent of the 24-hour period. A disturbance coefficient of 0.0 means that none of the zone of influence would be available (total displacement for the life of the activity) to the bear. A disturbance coefficient of 1.0 means that habitat effectiveness is not affected by the activity. A coefficient of 0.5 means that either one half of the bears are displaced, all the bears can use the area for only half the day, or any combination thereof. The result is the same--the ability to support bears is reduced by 50 percent. Table 2 shows the disturbance coefficients and zones of influence for the 13 activity groups.

Based on the assumption that bears are sensitive to multiple simultaneous sources of disturbance, disturbance within overlapping zones of influence is cumulative. In the habitat effectiveness calculation, the coefficient cannot be greater then 1.0.

The timing and duration of an activity may be as important as its disturbance coefficient in determining the effects on grizzly bears. Activity duration is another input coefficient into the submodel. This coefficient is simply the proportion (0.0 to 1.0) of the activity's duration in relation to the assessment period. The assessment period's length can vary with the detail of the analysis. For most applications a monthly assessment period, aggregated by season (spring, summer, fall, denning) seems appropriate. In special circumstances, daily assessment periods could be used. The capability to identify activity bottlenecks and opportunities for activity schedule coordination (fig. 2) can be refined with shorter assessment periods. These coefficients are multiplied against the product of the disturbance coefficient and optimal acres (habitat quality) to determine the habitat effectiveness for the entire assessment period.

Habitat quality determines the ability of a specific habitat to support a bear (habitat submodel). Disturbance determines the ability of a bear to use a specific habitat (displacement submodel). Habitat effectiveness is the product of these two submodels and identifies the habitat's actual capability. Habitat effectiveness is determined using (1) the polygon's optimal acres (for example, 40 acres of 0.5 quality rating equals 20 optimal acres), (2) percent of the unit affected by the zone of influence, and (3) the disturbance coefficient involved. The product of these three factors divided by the total optimal acres equals the percentage loss in habitat effectiveness.

The mortality submodel is only indirectly linked with the disturbance submodel. Displacement of bears from one area to another

Table 1. -- Definitions and examples of groups of human activities

MOTORIZED LINEAR: Motorized activities restricted to roads, trails, or linear corridor of travel such as aircraft flight corridors or seismic lines.

HIGH USE: Vehicle traffic exceeding one vehicle per daylight hour, including recurring low-elevation (less than 500 m above-ground) aircraft use, or seismic exploration without above-ground explosives.
LOW USE: Vehicle traffic less than one vehicle per daylight hour, generally associated with primitive roads or jeep trails.

MOTORIZED POINT: Motorized activities restricted to a specific point or area such as drilling operation, timber harvest activities, boat dock or ramp, generator site, or resort complex.

DIURNAL: Activities that produce loud equipment noises and occur only during the daylight hours.

HIGH INTENSITY: for example, major timber harvest activities, or day-use-only recreation complex.
LOW INTENSITY: for example, firewood cutting.

24-HOUR: Activities that produce loud equipment noises during a 24-hour operating period; for example, oil and gas drilling operation, mill or minesite, or resort complex.

MOTORIZED DISPERSED: Concentrated off-road vehicle activities that are not restricted to roads or trails, but that occur over broad areas. Use must be greater than one person per habitat component per day, including either overland (motorcycle) or over-snow (snowmobile) activities.

NONMOTORIZED LINEAR: Nonvehicle use associated with roads or trails, including roads closed to motor vehicle traffic.

HIGH USE: greater than three parties per day.
LOW USE: less than three parties per day.

NONMOTORIZED POINT: Human activities restricted to a specific point or area.

DIURNAL: for example, picnic ground or trailhead.
24-HOUR: for example, campground or summer home.

NONMOTORIZED DISPERSED: Human activities not restricted to a linear corridor or a specific point.

HIGH USE: Greater than one person per habitat component per day; for example, concentrated hunting use area.
LOW USE: Less than one person per habitat component per day; for example, area without easy access or without recreation attractions.

EXPLOSIVES: Activities in which very loud explosions are associated with the activity; for example, seismic exploration or road construction.

could influence the exposure to mortality risks identified in the mortality submodel. This relationship must be kept in mind when interpreting the model outputs.

Operation

The following procedures are used in the displacement submodel. (1) Identify and map all existing activities and human uses within a selected bear analysis unit. Complete a separate map for each assessment period based on identified activity durations, and selected assessment period stratification. (2) For each map, identify zones-of-influence and disturbance coefficients (from table 2). (3) Overlay habitat polygon maps and maps of activity zones-of-influence and identify for each polygon involved the percentage of polygon overlapping a given zone-of-influence, the appropriate disturbance coefficient (DC) for each zone-of-influence, and the appropriate duration coefficient for each zone-of-influence. Sum the disturbance coefficients for any overlapping zones-of-influence. (4) Compute the existing habitat effectiveness for each assessment period. Habitat quality must reflect appropriate seasonal rating. (5) Do the same for any proposed activities or human uses on a projected yearly basis for at least a 5-year planning period.

Table 2. -- Disturbance coefficients (DC) and zones of influence (ZI) for cover and noncover by activity group

Activity group	Cover		Noncover	
	ZI	DC	ZI	DC
Motorized Linear, high use	ridge line, 0.8 km	0.7	ridge line, 3.2 km	0.6
Motorized Linear, low use	ridge line, 0.8 km	0.9	ridge line, 3.2 km	0.8
Motorized Point, diurnal high intensity	ridge line, 1.6 km	0.5	ridge line, 3.2 km	0.4
Motorized Point, diurnal low intensity	ridge line, 1.6 km	0.7	ridge line, 3.2 km	0.6
Motorized Point, 24-Hour	ridge line, 1.6 km	0.2	ridge line, 3.2 km	0.1
Motorized Dispersed	N.A.	0.5	N.A.	0.4
Nonmotorized Linear, high use	0.2 km	0.8	line-of-sight, 0.8 km	0.7
Nonmotorized Linear, low use	none	1.0	line-of-sight, 0.8 km	0.9
Nonmotorized Point, diurnal	0.5 km	0.8	line-of-sight, 0.8 km	0.5
Nonmotorized Point, 24-Hour	0.5 km	0.5	line-of-sight, 0.8 km	0.3
Nonmotorized Dispersed, high use	N.A.	0.8	N.A.	0.7
Nonmotorized Dispersed, low use	N.A.	1.0	N.A.	0.9
Explosives	ridge line, 1.6 km	0.5	ridge line, 3.2 km	0.3

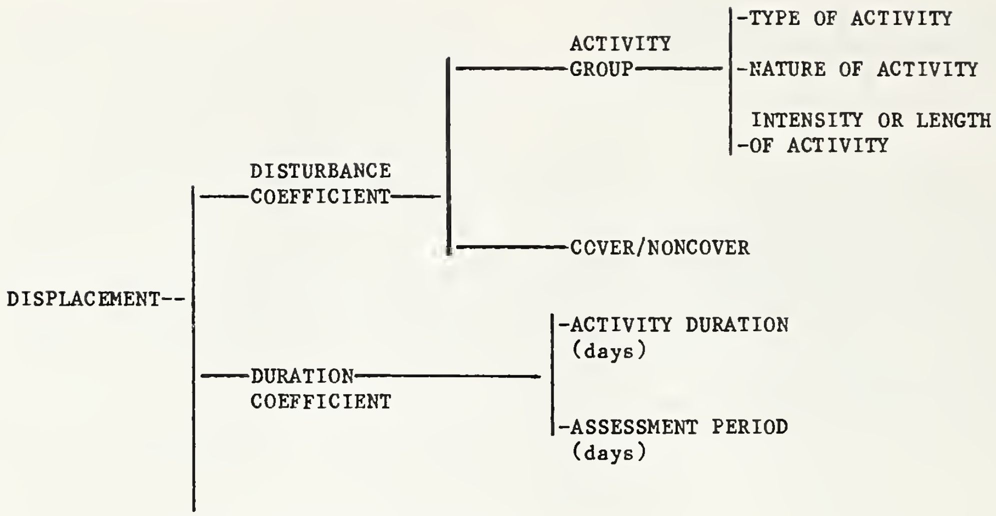

Figure 2. -- Displacement submodel diagram

MORTALITY SUBMODEL

Description

Human-caused mortality of grizzly bears within the Yellowstone ecosystem continues to be one of the most significant deterrents to population recovery. Thus, it is necessary to evaluate the risk of grizzly bear mortality due to human activity in the cumulative effects process. The mortality submodel provides a relative quantitative evaluation of this risk. The mortality submodel results in a mortality risk index for each bear management unit and or subunit.

Variables

Five basic variables are incorporated into the mortality submodel: (1) habitat quality, (2) nature of activity (point, linear, dispersed), (3) intensity of use, (4) availability of attractants, and (5) presence of firearms. These five basic variables combine to form distinct activity groups for which mortality risk indices were developed.

Habitat Quality--Deciding whether an activity occurs in low- or high-quality habitat is primarily based on management situation stratification under the "Interagency Grizzly Bear Guidelines." Activities occurring in Situation 1 are categorized as high-quality habitat while activities occurring in Situation 2 areas are categorized as low-quality habitat. Activities occurring in management Situation 3 areas and private lands fall into the quality habitat immediately adjacent to it. Although it is recognized that habitat quality can vary within a stratified area, stratification by management situation is currently the most consistent measure of habitat quality. As habitat mapping and habitat values are calculated according to the habitat submodel, habitat quality can be further refined.

Nature of Activity--Potential sources of illegal human-caused mortality can be categorized into the three groupings established in the displacement submodel. Point source activities include those activities by which humans may provide grizzly bears with a food attractant (backcountry camps with food, livestock feed, game meat; private homes; road-killed animals; developed campgrounds; bear-baiting stations; domestic sheep allotments).

Linear sources include roads, trails, and stream corridors where grizzly mortality could occur. Linear sources are divided into 10-mile segments (e.g., 20-mile road equals two sources, 8-mile trail equals one source). Dispersed sources would include those activities not associated with point and linear sources (e.g., hunting off the trail or road, berry picking, hiking off trail, cross country skiing). Dispersed sources are measured in units of people per habitat component per day. Mortalities associated with dispersed sources would be associated with random grizzly bear-human encounters.

Intensity of Use--Intensity of use on both linear and dispersed sources is categorized by the following activity levels:

Low use: Roads, fewer than one vehicle per daylight hour
Trails/Roads closed to vehicle, fewer than three parties per day
Dispersed, fewer than one person per habitat component per day

High use: Roads, more than one vehicle per daylight hour
Trails/Roads closed to vehicles, more than three parties per day
Dispersed, more than one person per habitat component per day

Availability of attractants--Availability of attractants at point sources of activity has been a significant factor in grizzly bear mortality throughout the ecosystem.

Food attractants available: if food storage requirements are in effect, but not enforced.
Food attractants unavailable: if food storage requirements are enforced.

Presence of firearms--Although grizzly bears are protected within the Yellowstone ecosystem, numerous mortalities by firearms have been recorded. Yellowstone and Grand Teton National Parks have regulations prohibiting the carrying of firearms, but the remainder of the area has no such regulations. Risk of bear mortality is considered higher on those lands allowing firearms.

Firearms present: if there are no restrictions on the public carrying firearms (generally includes all lands other than those within the National Parks).
Firearms absent: if firearms cannot be carried by the public (generally includes all lands within the National Parks).

Mortality risk indices for each activity group were developed by categorizing each human-caused grizzly mortality occurring in the ecosystem from 1973 to 1983. Mortality data were obtained from Kenneth J. Greer, Montana Department of Fish, Wildlife and Parks. Specific data on individual mortalities not available from K. Greer were obtained from individuals who have investigated the mortalities.

Mortalities were then adjusted upward for all categories with known losses due to firearms. This increase was based on the fact that all mortalities associated with firearms are not reported. Knight and Eberhardt (1985) reported that during the 1973 to 1983 period, calculations suggest that roughly 56 to 70 percent of the actual mortalities may have been recorded. Activity groups with known firearm losses were increased by a factor of 1.4 to reflect nonreported mortalities. The mortality risk index is simply the adjusted losses for each activity group divided by the total number of adjusted losses (table 3).

Due to a relatively small sample size, several categories have indices of 0. Managers must be aware that cumulative activities in these apparent low-risk categories may increase mortality risk.

As mortality factors may change over time due to improved management enforcement, mortality indices should be calculated annually using the past 5 years to reflect recent changes in mortality sources. This information will allow managers to evaluate and compare current management practices against the original data set. These mortality indices, however, would not be used in the calculation of the baseline mortality risk index for a bear management unit or subunit.

Assumptions

1. Mortalities include all dead bears as well as live bears removed from the ecosystem.

2. Only human-caused, illegal grizzly bear mortalities are included in the mortality indices. No legally killed bears (hunting) or mortalities associated with research activities are included.

3. Distribution of mortalities does not differ throughout the period in a manner that would significantly alter the mortality indices.

4. Prior to 1983, bears were removed at point sources because attractants were available, unless specific evidence indicated otherwise.

5. All human-caused but nonfirearm mortalities are reported.

Operation

1. List all existing activities from habitat effectiveness submodel for a bear management unit and/or subunit.

2. Categorize activities as to whether they are point, linear, or dispersed for each assessment period.

3. Assign to each activity values for intensity of use and availability of attractant.

4. Determine whether firearms can be legally associated with the activity.

5. Select mortality index from table 3 and assign to each existing activity.

6. Add mortality values for each bear management unit and/or subunit.

The value generated for each activity is not the probability of a grizzly bear mortality for a specific activity but an index of risk. The cumulative mortality index for the bear management unit or subunit is a quantitative assessment of the mortality opportunities. The higher the value, the higher the risk of a grizzly bear mortality.

Table 3. -- Mortality risk and indices by activity group

				Known Losses (1973-1983)	Adjusted Losses (1973-1983)	Mortality Index
HIGH HABITAT QUALITY	POINT	Attractant Available	Firearms	14	19.6	.29
			No Firearms	15	15	.22
		Attractant Unavailable	Firearms	0	0	.00
			No Firearms	1	1	.02
	LINEAR	High Use	Firearms	0	0	.00
			No Firearms	3	3	.04
		Low Use	Firearms	0	0	.00
			No Firearms	0	0	.00
	DISPERSED	High Use	Firearms	1	1.4	.02
			No Firearms	0	0	.00
		Low Use	Firearms	6	8.4	.13
			No Firearms	0	0	.00
LOW HABITAT QUALITY	POINT	Attractant Available	Firearms	7	9.8	.15
			No Firearms	9	9	.13
		Attractant Unavailable	Firearms	0	0	.00
			No Firearms	0	0	.00
	LINEAR	High Use	Firearms	0	0	.00
			No Firearms	0	0	.00
		Low Use	Firearms	0	0	.00
			No Firearms	0	0	.00
	DISPERSED	High Use	Firearms	0	0	.00
			No Firearms	0	0	.00
		Low Use	Firearms	0	0	.00
			No Firearms	0	0	.00

THRESHOLD LEVELS

A final step in the development of a cumulative effects model involves establishing and validating threshold levels. These thresholds represent the minimum acceptable levels of habitat effectiveness and mortality risks required for species recovery. Thresholds could vary by season and by bear management unit.

Ideally, thresholds for habitat effectiveness should provide for the energetic and spatial needs of the grizzly bear population during worst-case situations (seasonally and annually). One possible approach would be to compare worst-case home range <u>versus</u> lifetime home range (seasonal and annual ranges) of a representative set of adult female bears with multiyear histories of telemetry locations. Even approximate calculations of available energy for different seasons and years would greatly enhance our understanding and modeling of spatial needs of grizzly bears. By analyzing bears′ spatial use in areas of comparable energetic value but with differing levels of human activity, it may be possible to assess the influence of human activity.

Establishing and validating threshold levels based on bears′ response to varying environmental conditions and human activity will require habitat mapping of several bear management units and intensive analysis of the existing data. With declines occurring in the grizzly bear population index and in key population parameters (Knight and Eberhardt 1985), it would be desirable to establish interim thresholds for the habitat effectiveness value and the mortality index. The following thresholds for interim guidance are recommended throughout the Yellowstone ecosystem.

Habitat Effectiveness

Within each bear management unit, habitat effectiveness values should be retained at least at the current level. However, when the current level is below 80 percent of potential habitat effectiveness, reaching 80 percent becomes a minimim goal. To safeguard against losses of seasonally significant habitat, managers should measure and maintain suitable habitat on a seasonal basis.

Mortality Index

Human-caused grizzly bear mortality, particularly of adult females, is the key issue in conserving the grizzly bear population in the Yellowstone ecosystem (Knight and Eberhardt 1985). We recommend that the mortality index ceiling for each bear management unit be no higher than existing levels. Decreasing the existing index, particularly in the category of available attractants at point sources, should be an immediate priority.

MANAGEMENT OF CUMULATIVE EFFECTS

The cumulative effects model will enhance decision making for land and resource managers in several ways. First, it will provide the manager a quantified and graphic representation of the effective habitat values and mortality risks for the existing (as well as potential) situation. The manager then can use the computer to simulate the additive as well as the independent effects of different land uses (existing or proposed). In other words, the manager can ask a series of what if?? questions and explore the relative consequences. The CEM should also enable the manager to discriminate which land use is contributing most to the simulated effects (sensitivity) and whether it influences habitat, habitat use, and/or survivorship of grizzly bears. This can be done in space and through time and at different planning levels.

Hence, through the CEM, the manager can enhance decisions concerning grizzly bear recovery and other land management issues.

ACKNOWLEDGMENTS

For their contribution, we thank the many individuals and agencies with expertise and responsibilities related to grizzly bears and their management, including Dave Winn and Kim Barber, USDA Forest Service, Intermountain Region; Mark Orme, Targhee National Forest; Jon Swenson, Montana Department of Fish, Wildlife and Parks; and Dale Harms, USDI Fish and Wildlife Service. Substantial assistance and support was also provided by representatives of the Yellowstone Ecosystem Subcommittee of the Interagency Grizzly Bear Committee.

REFERENCES

Blanchard, B. M. Grizzly bear-habitat relationships in the Yellowstone area. Int. Conf. Bear Res. and Manage. 5:118-123, 1983.

Brannon, R. Influence of roads and developments on grizzly bears in Yellowstone National Park. Interagency Grizzly Bear Study Team Report, Bozeman, MT; 1984.

Cole, G. F. Grizzly bear-elk relationships in Yellowstone National Park. J. Wildl. Manage. 36:556-561, 1972.

Graham, D. C. Grizzly bear distribution, use of habitats, food habits and habitat characterization in Pelican and Hayden Valleys, Yellowstone National Park. Bozeman, MT: Montana State University, 1978. M.S. Thesis.

Judd, S. L., Knight, R. R.; and Blanchard, B. M. Denning of grizzly bears in the Yellowstone area. 6th Int. Conf. on Bear Res.and Manage. (In press.)

Knight, R. R., and Eberhardt, L. L. Population dynamics of Yellowstone grizzly bears. Ecology. 66(2):323-334; 1985.

Knight, R. R., Mattson, D. J., and Blanchard, B. M. Movements and habitat use of the Yellowstone grizzly bear. Interagency Grizzly Bear Study Team report to the Interagency Grizzly Bear Committee. Bozeman, MT, 1984, 177 p.

Schleyer, B. O. Activity patterns of grizzly bears in the Yellowstone ecosystem and their reproductive behavior, predation and use of carrion. Bozeman, MT: Montana State University, 1983. M.S. Thesis.

Schleyer, B. O., Jonkel, J. J., Rhoades, K. G., and Dunbar, D. M. The effects of recreation on grizzly bear behavior and habitat use. Interagency Grizzly Bear Study Team Report. Bozeman, MT. 1984; 83 p.

CARTOGRAPHIC MODELING: A METHOD OF CUMULATIVE EFFECTS APPRAISAL

David S. Winn and Kim R. Barber

ABSTRACT: The basic assumptions and implications of developing a wildlife habitat cartographic model are discussed. A cartographic model and Geographic Information System were used to evaluate the cumulative effects of management activities on free-ranging grizzly bear (*Ursus arctos horribilis*) habitat within the Greater Yellowstone Ecosystem. The habitat characteristics associated with bear unit values, habitat diversity, and edge use were evaluated by comparing habitat conditions in various buffer sizes surrounding grizzly bear radio location sites with a similar number of randomly located sites. The cartographic modeling process is outlined and the model's utility for evaluating management implications and research needs are summarized.

INTRODUCTION

The cumulative effects issue is not new. Its present modeling emphasis responds to a concern for a more holistic approach to the land and resource management of grizzly bear habitats and the need to evaluate the impacts of management activities at the ecosystem level.

As early as 1971 the National Environmental Policy Act required that the effects of management activities be examined in an integrated and far-reaching manner. More explicit guidelines for conducting these environmental analyses were provided by the Council on Environmental Quality (CEQ) in 1978. The Endangered Species Act (1973) requires that biological assessments evaluate the cumulative effects of land uses and management activities on grizzly bears (*Ursus arctos horribilis*). This Act defines cumulative effects as the combined effect upon a species or its habitat that results from an activity.

The assessment and evaluation of long-range impacts and consequences of any project include the vexing problem of estimating direct and indirect effects. In essence, what must be dealt with are the direct effects caused by an action, the indirect effects of that action, and the resulting chain of successional events within the habitat.

Paper presented at the Grizzly Bear Habitat Symposium, Missoula, MT, April 30-May 2, 1985.

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As with most models, data must be converted into information. Second, information must be converted into ideas that are clear, concise, and meaningful. In addition, we should not lose sight of the major planning objectives: converting data to useful information for the purpose of making management decisions.

Throughout the evolution of land management planning, various models have been developed. These models, in spite of their complexity, have the simple goal of converting data into information.

In addition, models can provide the following benefits:

1. Once the conceptual ideas and methods associated with data conversions and model development are documented and reviewed by the public, the planning "products" are generally accepted.

2. Several variables can be made to interact, which enhances our ability to accurately display and interpret an array of relationships.

3. Models provide a medium for learning and for gaining understanding.

4. Finally, models permit validation of the theories from which they are derived.

The primary purpose of this paper is to demonstrate a process, not to defend a model. In simplistic terms, we formulated rule sets, organized a data base, and tested hypotheses within the model. The goal of the process is to gain understanding and to ensure the recovery of wild, free-ranging grizzly bears within the ecosystems.

ESSENTIALS OF CARTOGRAPHIC-CUMULATIVE EFFECTS MODELS

Cartographic modeling is a process that reduces the task of combining several spatial information sets into one (fig. 1). This orderly transformation follows a biological rule set. These rule sets are merely mathematical descriptions of orderly biological relationships.

Generally speaking, cartographic models that successfully address land management issues have three similar characteristics:

1. Data are converted to information in an orderly biological sequence.

2. Basic processes are followed.

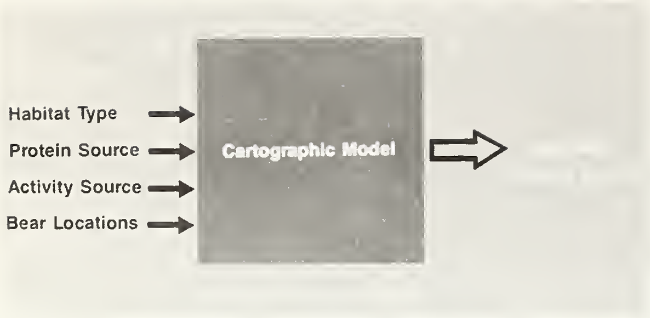

Figure 1.--General flow of habitat and bear locational information through the grizzly bear cartographic model.

3. The process can incorporate successional change.

The data relate to conditions that are spatial, such as the exact location of a bear's den, and nonspatial, such as the number of bears in a drainage.

Some of the more advanced techniques for converting resource data into meaningful management information include Geographic Information Systems (GIS). The GIS process provides for:

1. Identifying each data bit with a ground location.

2. Displaying data bits in relationship to time and space or in relationship to the spatial arrangements of other data bits. In other words, the juxtaposition of an array of plant communities and activities can be addressed.

3. Storing, analyzing, and displaying the results of the data set.

4. Displaying successional events.

Basic to the operation of a GIS is the conversion of habitat data to polygonal data. In this model, polygonal data represent the mapped outline of individual plant communities. The Greater Yellowstone Ecosystem (GYE) grizzly bear model defines the mapped polygons by their habitat type-overstory conditions. Polygons become the basic units of habitat and carry the attribute values. Polygons are assigned habitat type-overstory values that represent habitat potential, successional stage, and value to the bear.

The definition of rule sets is the most important element of bridging the gap between the cumulative effects process and the cartographic model. In the case of cumulative effects models, the rule set is merely the converting of spatial, nonspatial, and ecological relationships into mathematical functions. It is the power of these mathematical functions that makes the model useful. The processof converting these relationships into mathematical functions is important, because it makes it possible to distinguish science from planning and conjecture.

Romesburg (1981) suggested that persistent confusions associated with conceptual definitions, such as carrying capacity or viable populations and the reliability of knowledge gained from computer simulations, stem from either inadequate use or misuse of scientific methods. For purposes of cartographic modeling, Romesburg's thesis makes an additional important point: the domains of science and planning are philosophically distinct; yet because they share similar tools of analysis and simulation, their differences pass unnoticed.

It is this point that is critical to the interpretation and development of cartographic model rule sets. Ecological modelers and planners must recognize the essential difference that science uses fact as its standard for selection and planning relies on a value set.

The conflict in cumulative effects modeling arises when value is not fact or when value added to value is assumed to be fact. For example, in issues involving timber, the term "forage-cover ratio," depending on your point of view, spans a spectrum ranging from science to conjecture. The actual data base ratio is fact, but its biological interpretation at times can be construed to be fact.

In wildlife science, assumptions sometimes soften the impact of conjecture. There are two major assumptions that provide the foundation for the GYE Cumulative Effects Model: (1) habitat selection by grizzly bears does occur, and (2) area familiarity provides for efficient exploitations of the habitat resources. In other words, the process of becoming familiar with the habitat has survival advantages. This idea translates into the concept that area familiarity subsidizes efficiency (McLellan this volume).

From the premise that habitat selection occurs come three more assumptions implicit in the first:

1. Bears can detect resource differences.

2. Bears can determine which resources provide their needs.

3. Bears are capable of learning where to find these resources.

If these assumptions are correct, a bear will always be at a site it has selected and the sampling of bear locations will represent resource selection.

It was from the notion that grizzly bears actively select resources that a cumulative effects rule set was developed to appraise management activity-bear interactions within the Greater Yellowstone Ecosystem.

GREATER YELLOWSTONE CARTOGRAPHIC-CUMULATIVE EFFECTS MODEL

The concept of determining the cumulative effects for grizzly bears and their habitat is not new (Christensen and Madel 1982). It began in the northern forest ecosystems and has been evolving throughout several ecosystems for the last 4 years. The development of a cartographic model for specific ecosystems entails several initial steps:

1. The classification and mapping of habitat components.

2. The categorizing and mapping of land use activities.

3. The development of interactive habitat coefficients.

The general idea appears simple enough; however, the process of linking activity patterns, habitat quality evaluations, disturbance factors, and the risk of mortality is a cumbersome task.

The cartographic model developed for the Greater Yellowstone Ecosystem cumulative effects model incorporates a GIS that produces redefined polygon boundaries and summations of habitat component acres. This is accomplished with a series of vegetation-protein-activity overlays (Winn and Barber in press). A species-specific software outputs equivalent acres, diversity indexes, and bear unit values (fig. 2).

Bear management units are used as a standard for comparing management activities. These units, which are delineated by using grizzly bear radio locations and topographic features, serve to break the larger Greater Yellowstone Ecosystem into manageable areas. In addition, bear units facilitate the cumulative effects analysis process,

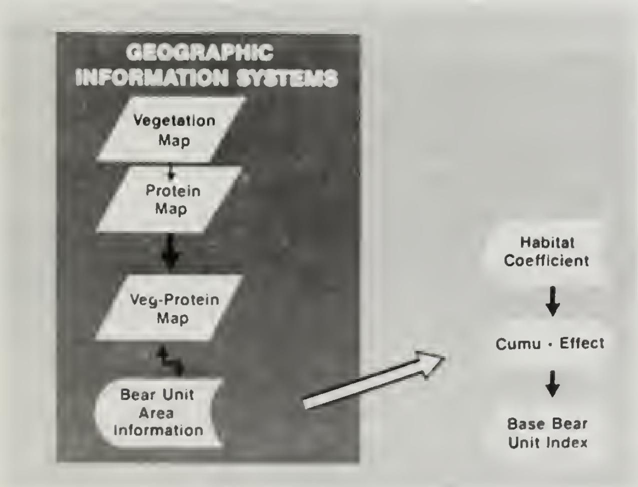

Figure 2.--Flow chart depicting the cartographic modeling of a bear unit index.

correspond to individual bear use patterns and behavioral ecology, moderate the washing-out effect associated with the analysis of management activities at the ecosystem level, and set a standard area size with which to compare interunit analyses.

Bear management units are further divided into subunits. The subunits, which are delineated on the basis of seasonal bear use patterns and interspersion of seasonal ranges, provide the optimal scale for landscape resolution and modeling of bear habitat use patterns. Within the model, the subunit represents the most energetically efficient area for the bear and is the basis for cumulative effects calculations.

The GYE Cumulative Effects Model consists of three submodels:

1. The habitat submodel incorporates the variables food, cover, habitat diversity, and seasonal feeding opportunities. The submodel outputs a relative habitat index (Mattson this volume; Weaver and others this volume).

2. The displacement submodel permits the interaction of management activities across a spectrum of activity intensity and duration. The submodel's function is to identify the area in which bears will be affected and the extent to which bear activity will be reduced (Weaver and others this volume).

3. The mortality submodel, which is not yet an active component, determines the risk of mortality associated with the interaction of habitat quality and activity duration and intensity (Weaver and others this volume).

In summary, the habitat submodel determines the capacity of habitat to support bears. The displacement submodel predicts the actual use of the area by bears. The outputs from the habitat and displacement submodels are used to calculate a habitat effectiveness index. It is this index that is used to evaluate management alternatives. To review the cartographic process, habitat components are mapped and each polygon is labeled with the model attributes that identify its habitat type-overstory condition and the presence or absence of concentrated protein food sources. This habitat layer and the existing management activity overlays are digitized.

Next, the model's displacement coefficients (table 1), which reflect management activity duration and intensity, are used to define the impacted buffer area around each activity. Then the effect for each management activity is calculated and aggregated into a subunit cumulative effects value.

Initial buffer areas calculated by the cartographic model were limited to individual forest and nonforest radii associated with specific activity displacement coefficients. The resultant area, a circle, was not sensitive to differences in cover-noncover coefficients.

Table 1.--Greater Yellowstone cumulative effects displacement coefficients[1] that define buffer and zone of influence radii for selected activities

Activity type	Displacement coefficient Forest	Nonforest
	- - - - - Miles - - - - -	
Motorized point	1.0	2.0
Nonmotorized point	.3	.5
Road	.5	2.0
Trail	.1	.5

[1]Weaver and others this volume.

To overcome the initial buffer's lack of cover sensitivity, the spoke file was developed. The computer-generated map file incorporates both noncover and cover displacement factors into a zone of influence. Radii at 3° intervals evaluated the presence of noncover or cover and defined the boundary of the zone of influence. In the example of a motorized activity (table 1), as radius passes through 1 mile of noncover, 50 percent of the buffer requirement is met. If the radius continues into cover for 1/2 mile, the buffer requirement is fulfilled. Thus, any given radius can pass through any combination of cover/noncover to fulfill the buffer requirement. When all the radii end points are connected, they outline the zone of influence. The procedure is simply the accumulation of proportional distances based on activity cover and noncover displacement coefficients.

The zone of influence is more sensitive to juxtaposition of vegetation types and smaller than initially constructed for buffer zones.

In broad terms, the activity buffers are overlaid on the vegetation-protein base. The GIS interacts with the displacement subroutine and the area of the impacted polygons is determined. The updated GIS area summary is transferred to the species-specific habitat coefficient subroutine, and polygons are reevaluated. The resulting cumulative effects are evaluated as equivalent acres (sum of individual polygon coefficient X polygon acres). Subunit equivalent acres are modified by an estimate of habitat diversity and summed into the final cumulative effects index.

MODEL TESTING

Major variables for the cumulative effects model were tested using the Pilot Peak (Shoshone National Forest) fall season vegetation data base and the selected displacement coefficients (table 1). The Pilot Peak area was chosen because it resembles characteristic size and habitat conditions of a bear management subunit. The area includes a minimal number of linear and point source activities. For purposes of the following discussion, we assumed these activities did not influence bear behavior.

To test the cumulative effects model, we compared calculated area characteristics and habitat type proportions of randomly located buffers to the overall bear subunit value. With the exception of habitat diversity, the random plots did not deviate significantly ($P \leq 0.05$) from the expected results. Thus, we accepted the premise that the random plots represented the base habitat condition. This step was necessary to eliminate biased estimators associated with buffer area size differences.

We then compared the randomly located buffers to similar-sized buffers associated with bear locations. Significant differences occurred among these comparisons.

The basic assumption associated with this comparative procedure is that in the absence of active selection by bears, habitat use would be proportional to its availability. Since we found resource use was not proportional to its availability, we concluded the model predicted that habitat selection by bears occurs.

Once this assumption was accepted, we took advantage of the validation process that is inherent within the cartographic model.

RESULTS AND DISCUSSION

Size of Zones of Influence

We compared the zone of influence calculations for random plots with bear relocations and found that:

1. As the zone of influence area increased, bear use was disproportionately associated with higher quality habitat; however, due to the interaction of the current diversity calculation, bear unit values are area-size dependent (fig. 3).

2. The initial diversity index, which represented an evaluation of cover and feeding opportunities, is strongly area-size dependent and its emphasis is exaggerated in the model (fig. 4). This is being corrected (Mattson in this volume).

3. Because the proportion of equivalent acres to total acres is not sensitive to unit area, we envision this proportion as a possible replacement for the diversity index as an indicator of habitat quality (fig. 5).

Use of Edge

We found the use of edge habitat to be disproportionate to the availability of edge and associated with forest cover (fig. 6). The model indicates that bears seek the edge ecotone but remain in cover. This finding is supported by the work of Blanchard (1980).

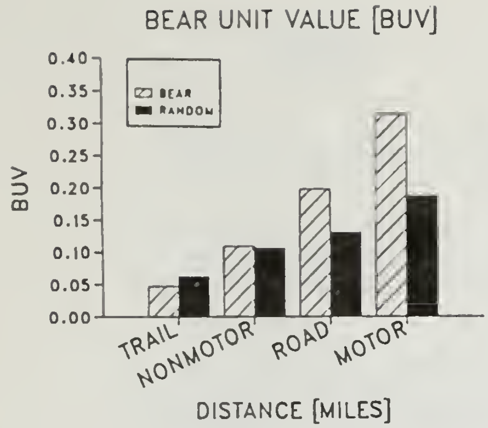

Figure 3.--Cartographic model validation calculation of bear unit values (BUV) for random and grizzly bear radio locations associated with selected displacement coefficients in the Pilot Peak area. Bear unit value = bear use disproportionately associated with higher quality habitat. Value increases with increasing size of area.

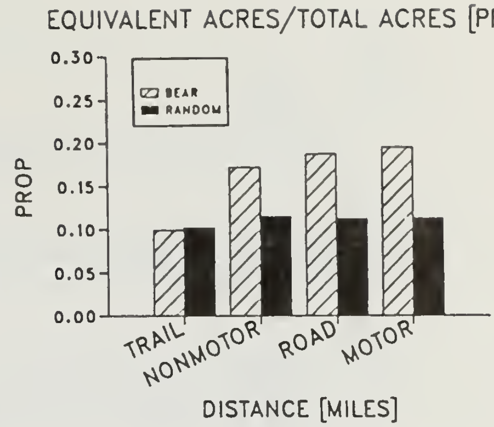

Figure 5.--Cartographic model validation calculations of equivalent acres/total acres (PROP) for random and grizzly bear radio locations associated with selected displacement coefficients in the Pilot Peak area. Equivalent acres/total acres = the most reliable indicator of habitat quality.

Figure 4.--Cartographic model validation calculation of diversity indices (DI) for random and grizzly bear radio locations associated with selected displacement coefficients in the Pilot Peak area. Diversity index = area size dependent. Emphasis exaggerated in model.

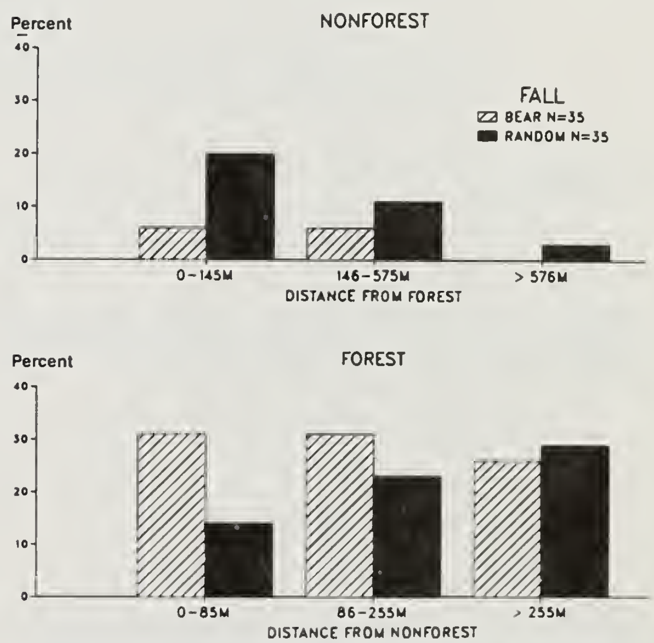

Figure 6.--Edge relationships of random and fall grizzly bear radio locations in forested and nonforested habitats in the Pilot Peak area.

Coefficient Values

We found habitat coefficient values associated with the proportional use of habitat cover types within the zones of influence were disproportionate and did not always correspond to the magnitude of the habitat coefficients (fig. 7). For example, the proportions of moist, high, and dry grasslands (coefficients of 0.293, 0.001, 0.001, respectively) did not follow the expected trend of use. This suggests that habitat values within the model should be more responsive to seasonal activity patterns and juxtaposition of vegetation polygons. A three-dimensional function that incorporates time, space, and habitat value might be more appropriate than the current two-dimensional array of coefficient values.

MANAGEMENT IMPLICATIONS

Our findings fall into two general areas: First, it appears that the application of cartographic models within the decision-making process provides for:

1. The simulation and evaluation of a series of management strategies.

2. Dealing with the spatial relationships, juxtaposition, and diversity.

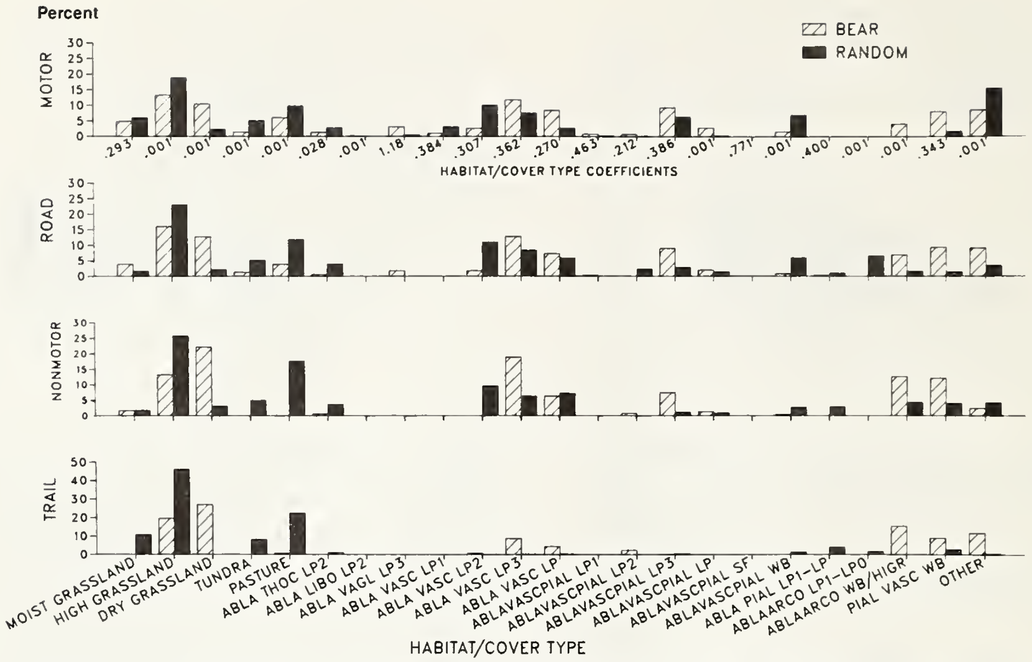

Figure 7. Proportions of habitat types included in zones of influence calculated for four displacement coefficients associated with random and fall grizzly bear radio locations in the Pilot Peak area.

3. Identifying precise areas with management opportunities.

4. Integrating other species into the analysis process.

Second, we have outlined a process that uses cartographic simulations to validate cumulative effects assumptions. This process includes:

1. Outlining the assumptions in detail.

2. Defining the rule set.

3. Organizing the data base.

4. Testing or validating the rule set.

We see a need for a stringent peer review of the model's basic assumptions, the level of accuracy required by the vegetation data base, and rule set validation.

In conclusion, our task was simple--merely to review and synthesize the work of others. It is our colleagues, who seized the opportunity and developed the initial rule sets for cumulative effects models, who are to be commended. We salute their collective and individual courage and effort; however, we should not lose sight of the paramount goal: our commitment as land managers to share the ecosystem with the great bear.

REFERENCES

Blanchard, B. M. Grizzly bear-habitat relationships in the Yellowstone area. Intl. Conf. Bear Res. and Manage. 5: 118-123; 1980.

Christensen, A. G.; Madel, M. J. A cumulative effects analysis process for grizzly bear habitat, Cabinet Mountains, Montana. In: Comer, Robert D; [and others], eds. Proceedings of national symposium on issues and technology in the management of impacted western wildlife; 1982 November 15-17; Steamboat Springs, CO. Boulder, CO: Thorne Ecological Institute; 1982: 124-132.

Romesburg, H. C. Wildlife science: gaining reliable knowledge. J. Wildl. Manage. 45(2): 293-313; 1981.

Winn, D. S.; Barber, K. Cartographic modeling: a method of cumulative effects appraisal. In: Comer, Robert D.; [and others], eds. Proceedings of national symposium on issues and technology in the management of impacted western wildlife; 1985 February 1-6; Glenwood Springs, CO. Boulder, CO: Thorne Ecological Institute; [in press].

Contreras, Glen P.; Evans, Keith, E., compilers. Proceedings—grizzly bear habitat symposium. 1985 April 30-May 2; Missoula, MT. General Technical Report INT-207. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 252 p.

Contains 33 papers and three abstracts including state-of-the-art information on grizzly bear habitat delineation and management. Topics are general habitat concerns, considerations, and conditions; mapping and evaluation; habitat improvement and coordination; and cumulative effects of activities on habitat.

KEYWORDS: *Ursus arctos*, threatened and endangered species, habitat research, habitat mapping, habitat evaluation, ecosystem analysis, cumulative effects.

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